Indrashil University

Department of Chemistry
School of Science

B.Sc. Chemistry Semesters I-IV

Course Profile
Academic Year: 2024 – 2025

B.Sc. Chemistry Semester I
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH1 101	Organic Chemistry-I	Major Discipline Core **(MDC)**	2-0-0	2
CH1 102	Inorganic Chemistry-I		2-0-0	2
CH1 103	Organic Chemistry -I Laboratory		0-0-4	2
CH1 104	Inorganic Chemistry-I Laboratory		0-0-4	2
CH1 105	Basic Physics	Minor Discipline Elective (**MDE**)	2-0-0	2
CH1 106	Basic Physics Laboratory		0-0-4	2
CH1 107	Chemistry in Daily Life	Multi-Disciplinary **(MDS)**	2-0-0	2
CH1 108	Chemistry in Daily Life Laboratory		0-0-4	2
CH1 109	English Language-1	Ability Enhancement Course **(AEC)**	2-0-0	2
CH1 110	Computer Technology & IT Skills for Chemists	Skill Enhancement Course **(SEC)**	1-0-2	2
CH1 111	Yoga for Wellness	Value Added Course **(VAC) /** Indian Knowledge System **(IKS)**	1-0-2	2
Total			**12L+0T+ 20P = 32 hrs.**	**22**

B.Sc. Chemistry Semester II
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH1 201	Organic Chemistry-II	Major Discipline Core (**MDC**)	2-0-0	2
CH1 202	Physical Chemistry-I		2-0-0	2
CH1 203	Organic Chemistry - II Laboratory		0-0-4	2
CH1 204	Physical Chemistry – I Laboratory		0-0-4	2
CH1 205	Physics of Semiconductor Devices	Minor Discipline Elective (**MDE**)	2-0-0	2
CH1 206	Physics of Semiconductor Devices Laboratory		0-0-4	2
CH1 207	Chemistry of Materials	Multi-Disciplinary (**MDS**)	2-0-0	2
CH1 208	Chemistry of Materials Laboratory		0-0-4	2
CH1 209	English Language-2	Ability Enhancement Course (**AEC**)	2-0-0	2
CH1 210	Techniques of Chemical Analysis	Skill Enhancement Course (**SEC**)	2-0-0	2
CH1 211	Health and Nutrition	Value Added Course (VAC)/ Indian Knowledge System (**IKS**)	2-0-0	2
Total			**14L+0T+ 16P = 30 hrs.**	**22**

B.Sc. Chemistry Semester III
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH2 101	Organic Chemistry-III	Major Discipline Core (**MDC**)	2-0-0	2
CH2 102	Inorganic Chemistry-II		2-0-0	2
CH2 103	Physical Chemistry-II		2-0-0	2
CH2 104	Organic Chemistry-III Laboratory		0-0-4	2
CH2 105	Inorganic Chemistry - II Laboratory		0-0-4	2
CH2 106	Physical Chemistry – II Laboratory		0-0-4	2
		Minor Discipline Elective (**MDE**)		
CH2 107	Semiconductor Devices	Multi-Disciplinary (**MDS**)	2-0-0	2
CH2 108	Semiconductor Devices Laboratory		0-0-4	2
CH2 109	Soft Skills	Ability Enhancement Course (**AEC**)	2-0-0	2
CH2 110	Laboratory Operations and Safety Measures	Skill Enhancement Course (**SEC**)	1-0-2	2
CH2 111	Indian Culture and Civilization	Value Added Course (VAC)/ Indian Knowledge System (**IKS**)	1-0-2	2
Total			**12L+0T+ 20P = 32 hrs.**	**22**

B.Sc. Chemistry Semester IV
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH2 201	Organic Chemistry-IV	Major Discipline Core (**MDC**)	2-0-0	2
CH2 202	Inorganic Chemistry-III		2-0-0	2
CH2 203	Physical Chemistry-III		2-0-0	2
CH2 204	Organic Chemistry – IV Laboratory		0-0-4	2
CH2 205	Inorganic Chemistry - III Laboratory		0-0-4	2
CH2 206	Physical Chemistry – III Laboratory		0-0-4	2
CH2 207	Application of Semiconductors	Minor Discipline Elective (**MDE**)	2-0-0	2
CH2 208	Application of Semiconductors Laboratory		0-0-4	2
		Multi-Disciplinary (**MDS**)		
CH2 209	Professional Communications	Ability Enhancement Course (**AEC**)	2-0-0	2
CH2 210	Software for Scientific Learning	Skill Enhancement Course (**SEC**)	2-0-0	2
CH2 211	Renewable Energy	Value Added Course (**VAC**)/ Indian Knowledge System (**IKS**)	2-0-0	2
Total			**14L+0T+ 16P = 30 hrs.**	**22**

B.Sc. Chemistry Semester V
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH3 101	Basics of Spectroscopy	Major Discipline Core **(MDC)**	2-0-0	2
CH3 102	Inorganic Chemistry-IV		2-0-0	2
CH3 103	Physical Chemistry-IV		2-0-0	2
CH3 104	Basics of Spectroscopy Laboratory		0-0-4	2
CH3 105	Inorganic Chemistry - IV Laboratory		0-0-4	2
CH3 106	Physical Chemistry – IV Laboratory		0-0-4	2
CH3 107	Semiconducting Materials for Microelectronics	Minor Discipline Elective **(MDE)**	2-0-0	2
CH3 108	Semiconducting Materials for Microelectronics Laboratory		0-0-4	2
CH3 109	Semiconducting Materials for Solar Energy		2-0-0	2
CH3 110	Semiconducting Materials for Solar Energy Laboratory		0-0-4	2
		Multi-Disciplinary **(MDS)**		
		Ability Enhancement Course **(AEC)**		
CH3 111	Tools for Scientific Exploration	Skill Enhancement Course **(SEC)**	2-0-0	2
		Value Added Course **(VAC)** / Indian Knowledge System **(IKS)**		
Total			**12L+0T+ 20P = 32 hrs.**	**22**

B.Sc. Chemistry Semester VI
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH3 201	Organometallics and Catalysis	Major Discipline Core **(MDC)**	2-0-0	2
CH3 202	Medicinal Chemistry		2-0-0	2
CH3 203	Spectroscopic Techniques		2-0-0	2
CH3 204	Organometallic and Catalysis Laboratory		0-0-4	2
CH3 205	Medicinal Chemistry Laboratory		0-0-4	2
CH3 206	Spectroscopic Techniques Laboratory		0-0-4	2
CH3 207	Semiconducting Materials for Photonics	Minor Discipline Elective **(MDE)**	2-0-0	2
CH3 208	Semiconducting Materials for Photonics Laboratory		0-0-4	2
		Multi-Disciplinary **(MDS)**		
CH3 209	Personality Development	Ability Enhancement Course **(AEC)**	2-0-0	2
		Skill Enhancement Course **(SEC)**		
		Value Added Course **(VAC)**/ Indian Knowledge System **(IKS)**		
CH3 210	Project	Research Project/On the Job Training **(RP/OJT)**	0-0-8	4
Total			10L+0T+24P = 34 hrs.	22

B.Sc. Chemistry Semester I
Detailed syllabus

Program: B. Sc. Chemistry	**Semester:** I
Course Code: CH1 101	**Course Name:** Organic Chemistry -I

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	CCE, ESE	50	40

Course Description: This course describes the basic knowledge of organic chemistry which covers nomenclature, hybridization, electronic displacement, and intermediate preparation. This course also explains the reaction mechanism of relevant name reactions. In this course, the students will learn about the stereochemistry of organic compounds. This course also covers reactions on unsaturated hydrocarbons.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Describe the nomenclature and electronic displacement of organic compounds

CLO2: Explain the physical and chemical properties of alkene, alkane, and alkyne

CLO3: Discuss the name reactions such as the Wurtz Reaction, Wurtz-Fittig reaction

CLO4: Implement the knowledge of electronic displacement and geometrical isomerism

Detailed Syllabus

Units	Content	Hours
I	**Organic Compounds**: Classification, and Nomenclature. Hybridization, Shapes of molecules Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles Reactive intermediates: Carbocations, carbanions, and free radicals. **Stereochemistry (a) Geometrical isomerism**: Fischer Projection, D/L nomenclature, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations. Optical Isomerism: optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral centers, diastereoisomers, racemic mixture and resolution, meso compounds. Relative and absolute configuration: nomenclature of chiral compounds, CIP rules, and R/S notations.	**15**
II	**Chemistry of Aliphatic Hydrocarbons: Alkanes**: General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity. Applications of hydrocarbons **Alkenes and Alkynes:** General methods of preparation, physical and chemical properties of alkenes and alkynes, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann elimination reaction. Electrophilic addition reactions with their mechanisms, oxidation reactions, the reaction of oxymercuration-demarcuration, hydroboration-oxidation, reduction, 1,2-and 1,4-addition reactions of conjugated enones; Allylic and benzylic bromination with suitable examples. Reactions of alkynes: Electrophilic and Nucleophilic additions. Oxidation and alkylation reactions of terminal alkynes.	**15**

Reference Materials:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2010, 7th Edition

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2002 6th Edition
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2002 5th Edition
4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
5. S. M. Mukherji, S. P. Singh and R. K. Kapoor. Narosa Publishers, Organic Chemistry, 2017, VOLUME 1.
6. A. Bahl and B. S Bahl. A Textbook of Organic Chemistry, Chand Publications, 2019, 22ND Ed.
7. R L Madan. Chemistry for Degree Students by S. Chand Publications. 2016, 1st Ed.

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 102	**Course name:** Inorganic Chemistry-I

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
2	-	2	30	Lecture	CCE, ESE	50	40

Course Description: This course deals with understanding atomic structure with different models, and the line-spectrum of hydrogen atoms. This course also explains different principles of filling the electrons in different orbitals. This course also delivers the idea about acids and bases with HSAB principle.
Course Learning Outcomes: At the end of this course students will be able to
CLO1: Describe the different models of the structure of the atom.
CLO2: Explain the concept of quantum numbers, orbit, and orbital
CLO3: Classify the line spectrum of the Hydrogen atom.
CLO4: Illustrate the concept of acids and bases and the usefulness of the HSAB Principle.

Detailed Syllabus

Units	**Content**	**Hours**
I	**Atomic Structure**: Structure of atom, Rutherford Model, and its defects, Bohr's model of the atom, radii, and Energy of an electron in Bohr orbit, the atomic spectrum/ line spectrum of the hydrogen atom. Bohr's theory of H-spectra. Shapes of s, p, d, and f orbitals. limitations of Bohr's theory. Quantum numbers and their significance, the concept of orbit and orbital, quantum numbers and orbitals relation, the spatial orientation of atomic orbital, shape of the orbital, ordering of orbital in multi-electron atoms, Pauli's Exclusion Principle, Hund's rule and orbital filling, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. Concept of Exchange energy (E_{ex}), stability of d^4 and d^9 system in terms of exchange energy.	**15**
II	**Concept of Acid & Bases**: Modern theory of acids and bases: The Arrhenius concept, The protonic concept (Bronsted-Lowry concept), The electronic concept (Lewis theory) and their demerits. Acid-Base adduct & Gutmann's rule. Hard and soft acids-bases principle (HSAB principle), concept of Hard Acids, Hard Bases, Soft Acids, Soft Bases, usefulness of HSAB principle, relative strength of Acids & Bases and effects of substituents and solvents on acidity and basicity, leveling effect of water. Strength of oxo and hydra acids, pH, K_w and, pk_a, super acids.	**15**

References Material:
1. J. D Lee, Concise Inorganic chemistry, Blackwell Science, 2008, 5th Ed.
2. R. P. Sarkar, General and Inorganic Chemistry, vol-I&II, New Central Book Agency, 2012,
3. F. A. Cotton, G. Wilkinson and Paul. L. Gaus, Basic Inorganic Chemistry, 2007, Wiley, 3RD Edition.
4. Dr. R. L. Madan, Chemistry for Degree Students, S Chand and Company, 2010, 2nd Ed.

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 103	**Course name:** Organic Chemistry-I Laboratory

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
-	4/week	2	60	Lab	CCE, ESE	50	40

Course Description: This is a practical course in organic chemistry. This course covers learning about the techniques of purification/crystallization of organic compounds. This course also deals with the determination of the melting point, identification, and separation of given organic compounds. This course also involves the synthesis of simple organic compounds such as acetanilide and *m*-nitrobenzoic acid.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Identify the suitable methods for the separation of organic mixtures.
CLO2: Understand the separation techniques and molecular chirality of organic molecules
CLO3: Demonstrate the preparation of acetanilide and *m*- nitrobenzoic acid.
CLO4: Connect the preparation of organic compound and separation technique

Detailed Practical

S. No.	Name of the Experiment	Hours
1	Determination of the melting points of given organic compounds by melting point apparatus	5
2	Simple distillation of a volatile compound from a mixture of components	5
3	Visualization of molecular chirality in the organic chemistry laboratory	5
4	Selection of suitable solvents for purification/crystallization of organic compounds	5
5	Identification and separation of the components in a given mixture of 2-amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography	5
6	Identification and separation of the sugars present in the given mixture by paper chromatography	5
7	Preparation of acetanilide from aniline using Zn/acetic acid (Green method)	10
8	Synthesis of *p*-nitro acetanilide from acetanilide using nitrating mixture	10
9	Hydrolysis of *m*-nitrobenzoate to *m*-nitrobenzoic acid (Conventional method)	10

Reading Materials:

1. B. S. Furniss; Vogel Textbook of Practical Organic Chemistry, 2011, Pearson Education
2. Arthur I. Vogel, Practical Organic Chemistry, 1995, Pearson Education Limited
3. A K Nad, B Mahapatraa Ghoshal, 2022, An Advanced Course In Practical Chemistry, Kolkata, New Central Book Agency, 2003, Third Ed..
4. V.K Ahluwalia and Sunita Dhingra, Practical Organic Chemistry, New Central Book Agency, 2017, First Ed.
5. N K Vishnoi, Advanced Practical Organic Chemistry, Vikas Publication, 2009, third edition.

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 104	**Course name:** Inorganic Chemistry-I Laboratory

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
--	4/week	2	60	Lab	CCE, ESE	50	40

Course Description: This course is a practical course of inorganic chemistry. This course prepares the students for upcoming years of intense organic/inorganic/analytical Chemistry laboratory courses. It involves simple calibration and preparation of solutions with various normality and molarity. It also teaches the students the determination of the acidity of a polybasic acid with simple chemical reactions.
Course learning outcome: At the end of this course, the students will learn to
CLO 1: Describe the concentration of solutions in normality, molarity, and percent wise
CLO 2: Discuss the determination of acidity/basicity of different chemicals
CLO 3: Classify the relative strength of acids and bases
CLO 4: Analyze the relation between acidity and basicity with pH

Detailed Syllabus

S. No.	**Name of the Experiment**	**Hours**
1	Titrimetric analysis: Calibration of unknown solutions.	5
2	Preparation of solutions with different molarity/normality of titrants	5
3	Determination of the density of unknown inorganic samples.	5
4	Determination of the pH of unknown acids and bases with the help of a pH meter.	5
5	Estimation of the strength of oxalic acid by titrating it with $KMnO_4$ solution	5
6	Determination of the molar concentration of a base from the known concentration of an acid.	5
	Virtual Experiments	
1	Making models for different orbitals with playdough ball and stick.	10
2	Demonstration of atomic orbitals using virtual labs (https://www.golabz.eu/lab/building-atomic-orbitals)	5
3	Predict the shell model depiction of an isotope based on the isotope symbol or name.	5
4	Describe how common tools (pH meter, conductivity, pH paper) help identify whether a solution is an acid or base and strong or weak and concentrated or dilute.	10

Reference Materials:
1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Ed., Orient Longman, 1989.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, 5th Ed., Orient Longman, 1982.
3. Inorganic Chemistry: A Laboratory Manual Hardcover – Import, 30 June 2016 by Mala Nath

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 105	**Course name:** Basic Physics

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	CCE, ESE	50	40

Course Description: In this course, students will learn the basics of dimensional analysis of any physical quantity, error analysis, and also vector algebra, which will help them understand the concept of physics at the beginner level. This course also explains the basics of the crystal structure of a solid material. This will also be useful for studying periodic systems and can be used to understand supercell and surface chemistry.
Course Learning Outcome: At the end of this course students will be able to
CLO1: Remember the basic concept of error analysis and vector algebra.
CLO2: Understand the basics of the crystal structure of solids.
CLO3: Solve the problems related to vector analysis using vector algebra with real-life examples.
CLO4: Analyze the concepts of different types of crystal structures and able to demonstrate them

Detailed Syllabus

Units	Content	Hours
I	**Dimensional, Error and Vector Analysis:** The international system of units, Measurement of length, Measurement of mass, Measurement of time, Accuracy, the precision of instruments and errors in measurement, Significant figures, Dimensions of physical quantities, Dimensional formulae and dimensional equations, Dimensional analysis and its applications Introduction to Scalar and Vectors, Dot and Cross Products, Triple Products and Its Physical Interpretation, ∇ Operator, Vector Operations: Gradient, Divergence and Curl, Their Physical Interpretation, Gauss' Divergence Theorem, Stokes Theorem (statement only).	18
II	**Crystal Properties Measures:** Types of solids, differences between crystalline and amorphous solids. Types of crystal, space lattice and unit cell of a crystal, different types of unit cells, interplanar spacing, simple crystal structure, symmetry operations, Types of Lattices structures of sodium chloride, cesium chloride, zinc blende, packing of crystals, radius ratio rules, Miller indices, X-ray Diffraction, Bragg's law, Reciprocal Lattice, properties of reciprocal lattice, Illustrative examples.	12

Reference Materials:

1. R. K. Hair, S.L. Gupta, Engineering Physics, 2006
2. R. K. Puri and V. K. Babbar, Solid State Physics, S. Chand Publication, 2007
3. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 2006
4. Resnick, Halliday and Walker, Fundamentals of Physics, Wiley, Extended version (10th Edition) 2010.

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 106	**Course name:** Basic Physics Laboratory

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
--	4/week	2	60	Practical	CCE, ESE	50	40

Course Description: This is a practical course in physics that deals with physical quantity, error analysis. This course also explains the experimental learning of the crystal structure of a solid material. This course will also help learn the radius of curvature of an object.
Course Learning Outcome: At the end of this course students will be able to
CLO1: Record the determination of physical properties.
CLO2: Estimate the crystal structure of solids.
CLO3: Calculate different physical properties like the density of the sample object.
CLO4: Operate the equipment using Newton's ring and the Thomson method.

Detailed Syllabus

S. No.	**Name of the Experiment**	**Hours**
1	To determine the diameter of a given cylinder/sphere.	8
2	To determine the density and volume of the sample block.	8
3	To determine the diameter of a given wire and the thickness of sample sheet.	8
4	To determine the radius of curvature of curve objects.	8
5	To determine the radius of curvature of a plano-convex lens by Newton's ring.	8
6	Determination of the molar concentration of a base from the known concentration of an acid.	8
7	To determine the value of the specific charge-to-mass ratio of an electron by Thomson method.	8
8	To study the magnetic field produced by a current carrying solenoid using a search coil.	4

Reference Materials:
1. C. L. Arora, B. Sc. Practical Physics, S. Chand & Company, 2010.
2. Harnam Singh and P. S. Hemne, B. Sc. Practical Physics, S. Chand Publication, 2000.

Program: B. Sc. Chemistry	**Semester:** I
Course Code: CH1 107	**Course Name:** Chemistry in Daily Life

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	CCE, ESE	50	40

Detailed Syllabus

Units	Content	Hours
I	**Dairy Products:** Composition of milk and milk products. Analysis of major/minor components, fat content, minerals in milk and butter. Estimation of added water in milk. Compare milk from different sources. Beverages: Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy, determination of methyl alcohol in alcoholic beverages.	**10**
II	**Food additives, adulterants, and contaminants:** Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, MSG, melamine, formalin, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate. **Vitamins:** Classification and nomenclature. Sources, deficiency diseases, and structures of Vitamin A1, Vitamin B1, Vitamin C, Vitamin D, Vitamin E & Vitamin K1. Comparison of vitamins from food and pills.	**10**
III	**Soap and Detergents:** Definition classification, history of soap synthesis, manufacturing of soaps and detergents, compositions and uses. **Chemistry of Cosmetics & Perfumes:** A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams, antiperspirants, and artificial flavors. **Chemistry of Pesticide:** General introduction to pesticides (natural and synthetic), benefits and adverse effects, uses of representative pesticides in the following classes: Organochlorines (DDT, gammaxene); Organophosphates (malathion, parathion); Carbamates (carbofuran and carbaryl); Hazards associated with the synthesis and use of pesticides.	**10**

Reference Materials:

1. B. K. Sharma: Introduction to Industrial Chemistry, Goel Publishing, Meerut, 1998
2. Medicinal Chemistry, Ashutosh Kar, New Age International Publishers, 2010
3. Fred Billmeyer: Textbook of polymer science; Willey 3rd Edition.
4. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4th Ed. New Age International (1998)
5. Handbook on Fertilizer Technology by Swaminathan and Goswamy, 6th Ed. 2001

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 108	**Course name:** Chemistry in Daily Life Laboratory

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
--	4/week	2	60	Practical	CCE, ESE	50	40

Course Description: This is a practical course of physics which deals with physical quantity, error analysis. This course also explains the experimental learning of the crystal structure of a solid material. This course will also be helpful in learning of radius of curvature of an object.
Course Learning Outcome: At the end of this course students will be able to
CLO1: Record the determination of physical properties.
CLO2: Estimate the crystal structure of solids.
CLO3: Calculate different physical properties like density of sample object.
CLO4: Operate the equipment like Newton's ring and Thomson method.

Detailed Experiments

S. No.	**Name of the Experiment**	**Hours**
1	To prepare and characterize soaps	8
2	To prepare and characterize detergents	8
3	Synthesis of aspirin from salicylic acid	8
4	Detection of aldehyde using Fehling's test	8
5	Test of unsaturation in ghee and oil using Bromine water	8
6	To analyze caffeine content in tea and coffee samples	10
7	To identification of cottonseed oil by Halphen's Test	10

Reference Materials:
1. A collection of interesting general chemistry experiments by Elias Anil J., University Press, 2012

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 109	**Course name:** English Language-1

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	CCE, ESE	50	20

Course Description: This course is planned to uplift the written and verbal English knowledge and communication skills in l students. The students will learn basic writing and understanding in English.
Course Learning Outcomes: At the end of this course the students will be able to
CLO1: Know the rules of grammar and sentence making
CLO2: Explain verbal communications and instructions, when done in English
CLO3: Paraphrase sentence framing and writing
CLO4: Classify the difficulty in English communications

Detailed Syllabus

Units	Content	Hours
I	Communication Skills: Importance of communication skills, communication cycle, types, flows, barriers, nonverbal communication Listening skills: Types of listening, barriers to effective listening, tips to improve listening skills	**15**
II	Grammar: Articles, prepositions, tenses, concord, adjectives & degrees of comparison, adverbs Speaking Skills: Impromptu, short situational dialogues/conversation, short speeches, presentations Reading Skills: Difference between skimming & scanning, identifying main idea and topic, guessing the meanings of words	**15**

Reference Materials:

1. Dr. Sanjay Kumar and Dr. Pushp Lata Communication Skills, Oxford University Press 2011 2nd Edition
2. Meenakshi Raman & Sangeeta Sharma Technical Communication; Principles and Practice Oxford University Press. 2015 Edition 3
3. M Ashraf Rizvi Effective Technical Communication – McGraw Hills Education, 2017, Second Edition
4. Vitthal Patel &Unnat Patel Text Book of Communication Skills Ria Publishing House 2013
5. Wren & Martin Key to High School English Grammar and Composition S Chand Publishing 2017

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 110	**Course name:** Computer Technology & IT Skills for Chemists

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	lax. Marks	Pass (%)
1	2/week	2	45	Lecture, laboratory	CCE, ESE	50	40

Course Description: In this course, students will learn the basics of computer skills; such as the concept of hardware and software, different types of number systems, etc. They will understand the types of data storage devices which are daily used. The students will also be able to learn basic operations such as MS Office for better data analysis, and graph interpretation in chemistry.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Remember the basics of computer software and hardware.

CLO2: Understand the mutual conversion between the different number systems.

CLO3: Describe different types of devices such as pointing devices and scanning devices

CLO4: Analyze the use of memory devices in real life.

Detailed Syllabus

Units	Content	Hours
I	**Introduction to Computers** Computer system: characteristics and capabilities. Computer Hardware and Software: Block Diagram of a Computer, Data Processing System, Storing Data, Processing Data. Types of Computers, Generation of Computers. Number systems: Decimal Number system, Binary number system, Octal, Hexadecimal number system	**12**
II	**Computer Peripherals and Basic Components** Storage Introduction to Input Devices: Categorizing Input Hardware, Keyboard, Direct Entry — Card Readers, Scanning Devices — O.M.R., Character Readers, Thumb Scanner, MICR, Smart Cards, Voice Input Devices, Pointing Devices Central Processing Unit: The Microprocessor, control unit, Buses, Main Memory, Main Memory (RAM) for microcomputers, Read Only Memory (ROM). Storage Devices: Storage Fundamentals, Primary and Secondary Storage, Hard Disks, Disk Cartridges, Optical Disks, CD ROM.	**18**

Reference Materials:

1. P. K. Sinha, Computer Fundamentals, BPB Publications, Sixth Edition, 2012.
2. V. Rajaraman, Introduction to Information Technology, PHI, Second Edition, 2008.
3. Suresh K Basandra, Computers Today, Galgotia Publications, 2018.
4. Peter Norton, Computing Fundamentals. 6th Edition, McGraw Hill-Osborne, 2010.

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 111	**Course name:** Yoga for Wellness

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
1	2/week	2	45	Lecture, lab	CEE, ESE	50	20

Course Description: This course deals with an understanding of mind and body through various types of physical postures, commonly known as Asanas. This course also teaches techniques of meditation, and breathing to keep a balance in everyone's daily life and maintain physical and mental health, flexibility, and endurance.
Course learning outcome: Through this course, the students will be able to
CLO1: Define the basic skills associated with yoga activities
CLO2: Discuss the ability to perform yoga movements in various combinations and forms.
CLO3: Understand the theoretical parts of yoga
CLO4: Apply yoga activities to citizens for their wellness

Syllabus

Units	**Content**	**Hours**
I	Different terminologies and meaning of yoga, types of yoga, illusions of yoga, benefits of yoga. Details about Ashtanga Yoga, and it's types. Understanding of complementary asanas with examples. Pranayama, types and it's forms, benefits of pranayama. Understanding of Pratyahar and examples.	**15**
II	Practicing Suryanamaskar, Padmasana, Gomukhasan, Dhanurasan, Tadasan, Padahastasan, Bhadrasan, Shavasan, Utthanpadasan, Purnatitli asan.	**30**

Reference Materials:

1. Swami Vivekananda Complete Book of Yoga Karma Yoga, Bhakti Yoga, Raja Yoga, Jnana Yoga. Arushi Book Enterprises 2023

B.Sc. Chemistry Semester II
Detailed syllabus:

CH1 201: Organic Chemistry-II (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 201	**Course name:** Organic Chemistry-II

Units	Content	Hours
I	**Chemistry of oxygenated Hydrocarbons**: **Alcohols:** preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt Blanc Reduction; Oxidation of diols by periodic acid and lead tetraacetate, Pinacol Pinacolone rearrangement; **Phenols**: Preparation and properties; Acidity and factors affecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism. **Ethers and Epoxides:** Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4.	**15**
II	**Chemistry of Carbonyl Compounds:** Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner,$LiAlH_4$, $NaBH_4$) Addition reactions of α, β- unsaturated carbonyl compounds: Michael addition.	**15**

Reading references

1. S. M. Mukherji and S.P. Sing. Mechanism and Structure in Organic Chemistry. Newagepublishers. 2017.
2. Morrison Boyd and Bhattacharjee. Organic Chemistry. Pearson Education India. 2010, 7th Ed.
3. I. L. Finar. Organic Chemistry (Volume I), Dorling Kindersley (India) Pvt. Ltd. Pearson Education. 1963, 4th Ed.
4. V. K Ahluwalia, P. Bhagat, R. Aggarwal, R. Chandra. Intermediate for Organic Synthesis. I. K. International. 2005.
5. T. W. G. Solomons, C. B. Fryhle, S. A. Snyder. Organic Chemistry. Wiley. 2016, 12th Ed.
6. R. Chandra, S. Singh, A. Singh. Organic Reactions and their Nomenclature. Arcler Education Inc. 2019.
7. Bhupinder Mehta and Manju Mehta. Organic Chemistry. PHI Learning Private Limited. 2015, 2nd Ed.

CH1 202: Physical Chemistry-I (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 202	**Course name:** Physical Chemistry-I

Units	Content	Hours
I	**Gaseous State:** Kinetic theory of gases, derivation of Boyle's law, Charles law, Avogadro's law from Kinetic theory, Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation, and application in explaining real gas behavior, virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, the relation between critical constants and van der Waals constants, and the law of corresponding states.	**15**
II	**Solid State:** Types of solids, differences between crystalline and amorphous solids. Types of crystal, space lattice and unit cell of a crystal, different types of unit cells, structures of sodium chloride, cesium chloride, zinc blende, packing of crystals, radius ratio rules, Miller indices, Bragg's law. **Liquid State:** Intermolecular forces in liquid, vapor pressure, boiling point, surface tension, surface energy, capillary action, and coefficient of viscosity of liquid. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids, refractive index, and Snell's law.	**15**

Reading references

Textbooks

1. Dr. R. L. Madan. Chemistry for Degree Students. S. Chand Publications New Delhi. 2022, 1st Ed.
2. B. R. Puri, Madan S. Pathania, L. R. Sharma. Principles of Physical Chemistry. Vishal Publishing. 2011.
3. R. Gurdeep. Advanced Physical Chemistry. Krishna Prakashan. 2018, 4th Ed.
4. B. R. Puri, L. R. Sharma. Principles of Physical Chemistry. Vishal Publishing. 2018, 1st Ed.

Reference books

1. P. L. Soni. Textbook of Physical Chemistry. P. L. Sultan Chand New Delhi. 2016.
2. C. Kittel. Introduction to Solid State Physics. John Wiley & Sons. 2018, 8th Ed.
3. Prutton and Marron. Principles of physical chemistry. 2017, 4th Ed.
4. Puri and Sharma. Text Book of Physical Chemistry. Vishal Publishing Co. 2020. 1st Ed.
5. K. L. Kapoor. Text Book of Physical Chemistry. McGraw Hill. 2020, 4th Ed.

CH1 203: Organic Chemistry-II Laboratory (L-T-P-C: 0-0-4-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 203	**Course name: Organic Chemistry-II Laboratory**

S. No.	Name of the Experiment	Hours
1	Analyzing the solubility of a given compound	5
2	Determination of the melting point of a given solid sample	5
3	Functional group analysis: characteristic tests for the aromatic amine group	5
4	Functional group analysis: characteristic tests for ketone group	5
5	Functional group analysis: characteristic tests for phenolic hydroxy group	5
6	Functional group analysis: characteristic tests for carboxylic acid group	5
7	Acetylation of one of the following compounds: amines (aniline, *o-, m-, p-* toluidine and *o-* , *m-*, *p*-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method: i. Using the conventional method. ii. Using a green approach	10
8	Oxidation of ethanol/ isopropanol (Iodoform reaction	10
9	Selective reduction of meta dinitrobenzene to m-nitroaniline	10

Reading references

1. B. S. Furniss. Vogel Textbook of Practical Organic Chemistry. Pearson Education. 2011,
2. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and Smith, P. W. G. Textbook of Practical 3. Organic Chemistry. Prentice-Hall. 1996, 5th Ed.
4. A. K. Nad and B Mahapatra. An Advanced Course in Practical Chemistry. New Central Book Agency. 2022, 3rd Ed.
5. V. K Ahluwalia and Sunita Dhingra. Practical Organic Chemistry. New Central Book Agency. 2017, 1st Ed.
6. N. K. Vishnoi. Advanced Practical Organic Chemistry. Vikas Publication. 2009, 3rd Ed.

CH1 204: Physical Chemistry - I Laboratory (L-T-P-C: 0-0-4-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 204	**Course name:** Physical Chemistry - I Laboratory

S. No.	Objective	Hours
1.	Demonstration of Kinetic Theory of Gas at different temperatures. (https://sciencing.com/how-8211482-convert-atm-pressure-celsius.html)	**4**
2.	Comparative analysis of physical properties of different liquids. (https://www.youtube.com/watch?v=jFWjjUKwCAk)	**4**
3.	Study of different states of matter (using ice cream bags)	**4**
4.	Determination of surface tension of liquid using various analytical samples	**4**
5.	Study of the variation of surface tension of a detergent solution with concentration.	**4**
6.	Estimation of viscosity coefficient of various analytical liquid samples by Ostwald's viscometry.	**4**
7.	Determination of percent composition of a binary mixture by using surface tension	**4**
8.	Determination of specific refractivity of a given liquid	**2**

Reading references

1. B. D. Khosla, V. C. Garg, Adarsh Gulati. Senior Practical Physical Chemistry. R. Chand & Delhi. 2018.
2. B. Viswanathan, P. S. Raghavan. Practical Physical Chemistry. Navi Mumbai Viva Books Private Limited. 2017.
3. A. K Nad, B. Mahapatra, A. Ghoshal. An Advanced Course in Practical Chemistry Paperback, New Central Book Agency P LTD. 2022.
4. B. Vishwanathan and P.S. Raghavan. Practical Physical Chemistry. Viva Books. 2012.

CH1 205: Physics of Semiconductor Devices (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** I
Course code: CH1 205	**Course name:** Physics of Semiconductor Devices

Units	Content	Hours
I	Band Theory of Solids: Introduction, Metals, Insulators and Semiconductors, Energy band gap, Fermi Level and Fermi energy, Types of magnetic material, Superconductivity, Properties of superconductors, Types of superconductors (Type I and Type II), London's Penetration depth, Applications of Superconductors.	**15**
II	PN Junction diode, FB and RB condition for PN junction and IV characteristics, LED, Half wave-full wave rectifier, Photodiode, Varactor Diode, Filter circuits: L, C and Π type filters, Transistor, IV characteristics of CE mode, Binary-octal-hex decimal number system and mutual conversions, Illustrative examples.	**15**

Reading references
Textbooks

1. R. K. Puri and V. K. Babbar. Solid State Physics. S. Chand & Co. Ltd. 2010.
2. V. K. Mehta. Principles of Electronics. S. Chand & Co. Ltd. 2014, 7th Ed.
3. A. Bieser. Concepts of Modern Physics. Tata McGraw-Hill. 2002, 6th Ed.

Reference books:

1. R. K. Hair and S. L. Gupta**.** Engineering Physics. Dhanpat Rai. 2012.
2. Charles Kittel. Introduction to Solid State Physics. John Wiley & Sons. 2018, 8th Ed.
3. S. M. Sze and Kwok K. Ng. Physics of Semiconductor Devices. Wiley. 1996.
4. P. Bhattacharya. Semiconductor Opto-Electronic Devices. Prentice Hall. 1996. 2nd Ed.
5. M. K. Achuthan and K. N. Bhat. Fundamentals of Semiconductor Devices. McGraw Hill Education. 2007. 1st Ed.
6. J. Allison. Electronic Engineering Materials and Devices. McGraw Hill Education. 1990.

CH1 206: Physics of Semiconductor Devices Laboratory (L-T-P-C: 0-0-4-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 206	**Course name: Physics of Semiconductor Devices Laboratory**

S. No.	Objectives	Hours
1.	Determination of lengths of different objects using vernier caliper and screw gauge.	**4**
2.	Verification of the Truth Table of Logic Gates.	**4**
3.	Verification of the functionality of the PN junction diode in forward bias and reverse bias.	**4**
4.	Analysis of the charging & discharging of a given capacitor.	**4**
5.	Analysis of the frequency response characteristics of a series and parallel resonance circuits	**4**
6.	Construction of a half-wave and full-wave rectifier circuit and analysis of its output.	**2**
7.	Determination of the Hall voltage developed across the sample material and the Hall coefficient of the sample material.	**4**
8.	Determination of the provided high resistance by the substitution method	**2**
9.	Evaluation of frequency response of a single pnp transistor using the common emitter transistor amplifier	**2**

Reading references

1. R. K. Puri and V. K. Babbar. Solid State Physics. S. Chand & Co. Ltd. 2010.
2. V. K. Mehta. Principles of Electronics. S. Chand & Co. Ltd. 2014, 7th Ed.
3. https://www.amrita.edu/course/physics-semiconductor-devices/

CH1 207: Chemistry of Materials (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 207	**Course name:** Chemistry of Materials

Units	Content	Hours
I	**Solid State Materials:** Basic concept, Lattice energy, size effects, covalent character in ionic bonds, structures of complex solids, conductivity in ionic solids, and solids held together by different interactions. **Amorphous and Porous Materials:** Crystalline vs. amorphous solids, glass formation, structural models of amorphous materials, evolution and development of porous materials, the chemistry of microporous materials, mesoporous materials, zeolite and zeolite-like materials, polymers and carbon materials in zeolites.	**10**
II	**Polymeric Materials:** Different schemes of classification of polymers, polymer nomenclature, molecular forces, chemical bonding in polymers, and texture of polymers. Synthesis, characterization techniques, properties, and applications of any well-known polymer. Conducting polymers, porous polymers. **Dielectric Materials:** Dielectric constant and polarizability, insulating materials, ferroelectrics, piezoelectrics, measurement of dielectric properties. Representative examples of specific dielectric materials, preparation, characterization techniques, basic properties, and applications. **Silicates:** Glassy state and its properties, classification (silicate and nonsilicate glasses). Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, colored glass, and photosensitive glass. **Nanomaterials:** Properties of nanomaterials, role of size and shape, chemical and biological methods for synthesis, basic characterization techniques.	**20**

Reading references

Textbooks

1. *General Chemistry: Principles, Patterns, and Applications*. Saylor Foundation, 2011.
2. A. R. West. Solid State Chemistry and its applications. Wiley. 2014, 2nd Ed.
3. J. Shackelford. *Introduction to Materials Science for Engineers*. Pearson. 2004, 6th Ed.
4. B. D. Cullity and S. R. Stock. *Elements of X-Ray Diffraction*. Pearson. 2001, 3rd Ed.
5. B. Averill and P. Eldredge. *Chemistry: Principles, Patterns, and Applications*. Pearson. 2007.

Reference books

1. A.K. Cheetham and P. Day, Solid State Chemistry: 1. Techniques and 2. Applications
2. P.A. Cox, The electronic structure and chemistry of solids
3. Klabunde, K. J., Ed. *Nanoscale Materials in Chemistry*, Wiley Interscience (2001)
4. N.N. Greenwood, Ionic crystal, lattice defect and non-stoichiometry
5. C.N.R. Rao and J. Gopalakrishnan, New directions in solid state chemistry

Web reference

https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-2010/pages/syllabus/

CH1 208: Chemistry of Materials Laboratory (L-T-P-C: 0-0-4-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 208	**Course name:** Chemistry of Materials Laboratory

S. No.	Objectives	Hours
1.	Analysis of the crystal structure of a given sample	4
2.	Identification and analysis of crystal imperfections in a given sample	4
3.	Observation and analysis of the thermosetting of plastic	4
4.	Synthesis and characterization of nanoparticles by sol-gel method	4
5.	Analysis of the properties of various types of plastics	4
6.	Preparation and characterization of CNTs	4
7.	Preparation and characterization of metallic nanoparticles	4
8.	Preparation of porous materials	2

Suggested Reading/Reference

1. A.K. Cheetham and P. Day, Solid State Chemistry: 1. Techniques and 2. Applications
2. P.A. Cox, The Electronic Structure and Chemistry of Solids
3. Klabunde, K. J., Ed. *Nanoscale Materials in Chemistry*, Wiley Interscience (2001)
4. N.N. Greenwood, Ionic Crystal, Lattice Defect and Non-Stoichiometry
5. C.N.R. Rao and J. Gopalakrishnan, New Directions in Solid State Chemistry

CH1 209: English Language-2 (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 209	**Course name:** English Language-2

Units	Content	Hours
I	**Communication Skills, Speaking & GrammarCommunication & Speaking Skills** Oral Communication: 6 C's of Communication, conversation in pairs with the help of Cue-cards and effective presentation strategy, P's of presentation preparing outline of the presentation. Explaining their ideas and feelings in simple English. Situations will be drawn from their everyday experiences, group discussion dynamics, and brainstorming on current news affairs. **Advance Grammar and Vocabulary** Voice –Active/Passive, Use of Adjective and Adverb, Difference between Simple, Compound and Complex sentences, confusables, affixes, idioms, and one-word substitutes.	15
II	**Reading Skills & Writing SkillsReading Skills** Reading comprehension of general passages, Reading Technicalpassages, Reading General passages, Reading cases/cases and advertisements from newspaper/magazines. **Writing Skills** Defining report, the purpose of report writing & its significance, explaining various characteristics, types, and elements of report writing Discussing the difference between reference and bibliography,Explaining the difference between Resume and Bio-data, preparing resume, Explaining Précis writing and its significance and practice, Preparing Advertisement	15

Reading references

1. Dr. Sanjay Kumar and Dr. PushpLata. Communication Skills, A Workbook. Oxford University Press. 2018, 1st Ed.
2. Meenakshi Raman and Sangeeta Sharma. Technical Communication; Principles and Practice. Oxford University Press. 2015, 3rd Ed.
3. R. C. Sharma and Krishna Mohan. Business Correspondence and Report writing. Tata Mcgraw Hill. 2015, 8th Ed.

M Ashraf Rizvi. Effective Technical Communication. SIA Publishers. 2022, Latest Ed.

CH1 210: Techniques of Chemical Analysis (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 210	**Course name:** Techniques of Chemical Analysis

Units	Content	Hours
I	Chromatographic Techniques: Principles of chromatographic separation, Rf factor, paper and thin layer chromatography, solvent system, eluents	**7**
II	Chemical Conductivity: Types of solutions, electrolysis and electrolytes,conductance in electrolytic solutions, specific and molar conductivity variations of conductivity with concentration	**8**

Experiments to be performed		
S. No.	**Objectives**	**Hours**
1.	Chromatographic Techniques: Separation of two or more components by Paper Chromatography	6
2.	Separation of two or more components by Thin Layer Chromatography	6
3.	Comparison of Rf value in different Solvent System	4
4.	Chemical Conductivity: Measurement of chemical conductivity	6
5.	Determination of pH by pH meter	4
6.	Comparison of conductivity of different electrolytes	4

Reading references

1. A Hand Book of Chromatography by Anna P. G. Nikalje, Scholar's Press VerlagOmniscriptam, Deutschland, Germany. ISBN: 978-3-330-65032-9.

CH1 211: Health and Nutrition (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** II
Course code: CH1 211	**Course name:** Health and Nutrition

Units	Content	Hours
I	**Food and Nutrition:** The basics of plant and animal foods, their types, structure and composition, and nutritional value. Balance diet, Calorificvalues of different food items. Cereals and MilletsPulses Fats & oils Fruits and vegetables milk and milk products	**15**
II	**Food Borne Diseases:** Types and Control Measures, Food Infection and Intoxication- Bacteria and Non-bacteria, Probiotics-Nutritional and therapeutic aspects,Therapeutic values of fermented foods Diseases related to food, vitamins and mineral deficiencies	**15**

Reading references

1. B. Srilakshmi., (2018). Food Science. K. R., New Age International Pvt.Ltd. 7th Edition.
2. L. H. Meyer., (2006). Food Chemistry. CBS Publishers and Distributors,New Edition.
3. B. Poornima., (2012). Fundamentals of Food Science, Technology andProcessing and Preservation. Centrum Press.

B.Sc. Chemistry Semester III
Detailed syllabus:

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 101	**Course Name:** Organic Chemistry -III

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	CCE & ESE	50	40

Course Description: This course deals with understanding the chemistry of oxygenated hydrocarbon and carbonyl compounds. It covers preparation, physical and chemical properties, and reactivity of oxygenated hydrocarbon and carbonyl compounds. This course also explains the reaction mechanism of related name reactions.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Remember the related name reaction of alcohols and carbonyl compounds
CLO2: Understand the mechanism name reactions related to carbonyl compounds
CLO3: Apply the knowledge of name reactions of carbonyl compounds
CLO4: Explain the reaction mechanism of alcohols and carbonyl compounds

Detailed Syllabus

Units	Content	Hours
I	**Carboxylic Acids and their Derivatives**: General methods of preparation, physical properties and reactions of monocarboxylic acids, effect of substituents on acidic strength. Typical reactions of dicarboxylic acids, hydroxy acids, and unsaturated acids. Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement. **Aromaticity of polynuclear hydrocarbons:** structure elucidation of naphthalene; Preparation and properties of naphthalene, phenanthrene, and anthracene.	**15**
II	**Nitrogen Containing Functional Groups:** Preparation and important reactions of nitro compounds, nitriles and isonitriles. Amines: Preparation and properties: Effect of substituent and solvent on basicity; Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications. **Heterocyclic Compounds**: Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Indole(Fischer indole synthesis and	**15**

	Madelung synthesis), Quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller, Pictat-Spengler reaction, Pomeranz-Fritsch reaction).	

Reading references

1. Morrison Boyd and Bhattacharjee. Organic Chemistry. Pearson Education India. 2010, 7th Ed.
2. I. L. Finar. Organic Chemistry (Volume I), Dorling Kindersley (India) Pvt. Ltd. Pearson Education. 1963, 4th Ed.
3. I. L. Finar. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. Pearson Education. 2002, 5th Ed.
4. R. M. Acheson. Introduction to the Chemistry of Heterocyclic Compounds. John Welly & Sons. 2008, 3rd Ed.
5. T. W. Graham Solomons. Organic Chemistry. John Wiley & Sons, Inc. 2017, 12th Ed.
6. P. S. Kalsi. Textbook of Organic Chemistry. New Age International (P) Ltd. Pub. 2000, 1st Ed.
7. Greeves, Warren, and Wothers Clayden. Organic Chemistry. Oxford University Press. 2014, 2nd Ed.
8. J. Singh, S. M. Ali, J. Singh. Natural Product Chemistry. Pragati Prakashan. 2010.

Program: B. Sc. Chemistry	**Semester:** III
Course Code: CH2 102	**Course name:** Inorganic Chemistry-II

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	--	2	30	Lecture	CCE, ESE	50	40

Course Description: This course deals with understanding different chemical bonding in a molecule. This course also explains polarity, the deformation of ions, and the consequences of deformation. This course also delivers the idea about molecular orbital theory (MOT) of some small molecules and weak chemical forces including H-bonding.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Define different bonding patterns in a molecule.
CLO2: Predict the geometry of any molecule using VSEPR theory.
CLO3: Apply the concept of Fazan's rule, Born-Haber Cycle, Born-Lande equation.
CLO4: Analyze different weak intermolecular forces.

Detailed Syllabus

Units	Content	Hours
I	**Chemical Bonding**: Lewis structure, Resonance and resonance energy, Formal charge, multiple bonding (σ and π bond approach), and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences of polarization, bond strength bond order and bond energy relations, Hydrogen bond, intramolecular hydrogen bond and intermolecular hydrogen bond, Hybridization of orbitals, Valence Bond theory and its limitations, types of hybridization and shapes of inorganic molecules and ions, VSEPR theory to NH_3, H_3O^+, SF_4, ClF_3, ICl_2^-, and H_2O. Bent's rule, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2.	10
II	**Ionic Bond**: General characteristics of ionic compounds, melting point, boiling point, hardness, solubility, conductance, radius ratio rule, coordination number, limitation of radius-ratio rule, lattice energy, Born-Lande equation for lattice energy, comparison between lattice energy and hydration energy, Born-Haber cycle, metallic bond, Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Metallic Bond.	10
III	**Non-bonding interaction:** Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Hydrogen bond, intramolecular and intermolecular hydrogen bond, Application of hydrogen bonding, factors determining Van der Waal's force, Repulsive forces, Hydrogen bonding: types, applications, Effects of chemical forces	10

Reading references

1. J. D. Lee. Concise Inorganic Chemistry. Blackwell Science. 2008, 5th Ed.

2. R. P. Sarkar. General and Inorganic Chemistry. vol-I&II. New Central Book Agency. 2012.
3. F. A. Cotton, G. Wilkinson, Paul. L. Gaus. Basic Inorganic Chemistry. Wiley. 2007, 3rd Ed.
4. Dr. R. L. Madan. Chemistry for degree students. S Chand and Company Limited. 2010, 2nd Ed.

Program: B. Sc. Chemistry	**Semester:** III
Course Code: CH2 103	**Course Name:** Physical Chemistry II

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
2	-	2	30	Lecture	ESE	50	40

Course Description: This course is designed to fully understand the major concepts of Chemical Thermodynamics. It covers principles of classical thermodynamics. Develops understanding of mass, energy, heat, work, efficiency, entropy, enthalpy, Gibbs free energy, ideal and real thermodynamic cycles and processes. The course also covers the first, second, third, and zeroth laws of thermodynamics and concepts in thermochemistry. More emphasis will be given to various free energy functions.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Recognize and use the thermodynamic parameters correctly.

CLO2: Understand the first, second, third, and zeroth laws of thermodynamics.

CLO3: Apply the knowledge of chemical thermodynamics to interpret the chemical reactions.

CLO4: Correlate thermodynamics to solve practical problems in physical and chemical systems.

Detailed Syllabus

Units	Content	Hours
I	Intensive and extensive variables; state and path functions; isolated, closed, and open systems; zeroth law of thermodynamics. **First law:** Concept of heat, work, internal energy, and statement of first law; enthalpy, *H*, the relation between heat capacities, calculations of *Q*, *W*, *U,* and *H* for reversible, irreversible, and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. **Thermochemistry:** Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy, and resonance energy from thermochemical data, the effect of temperature (Kirchhoff's equations) and pressure on the enthalpy of reactions. Adiabatic flame temperature, explosion temperature.	**15**
II	**Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. **Third Law:** Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. **Free Energy Functions:** Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. Partial molar quantities, dependence of thermodynamic parameters on	**15**

	composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases	

Reading references

Textbooks

1. G. W. Castellan Physical Chemistry by Narosa Publication 2004 3rd Edition
2. P. C. Rakshit Physical Chemistry Levant Books 2020 7th Edition
3. R. L. Madan Chemistry for Degree Students S. Chand Publications, 2022 1st Edition.
4. Advanced Physical Chemistry, Raj, Gurdeep, Meerut: Krishna Prakashan, 2018 4th Edition
5. Principles of Physical Chemistry, Puri, B. R., Sharma, L. R., Vishal Publishing CO. Delhi: 2016 4th Edition

Reference books

6. Prutton and Maron. Principles of Physical Chemistry Oxford & IBH Publishing Ltd., 2017
7. P. K. Nag Basics and Applied Thermodynamics Tata Mcgraw-Hill 2006, 8th Edition

Program: B. Sc. Chemistry	**Semester:** III
Course Code: CH2 104	**Course Name:** Organic Chemistry II Laboratory

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
--	4/week	2	60	Lab	CCE & ESE	50	40

Detailed Practical

S. No.	**Name of the Experiment**	**Hours**
1.	Execution of Aldol condensation between acetone and benzaldehyde	6
2.	Execution of Hofmann-bromamide rearrangement for Ph-CO-NH2 yielding PhNH2	6
3.	Execution of Curtius rearrangement with a practically suitable example	6
4.	Synthesis of Gabriel phthalimide through a practically suitable example	6
5.	Identification of primary amines through Carbylamine test (PhNH2 to PhNC)	6
6.	Execution of Mannich condensation reaction with benzaldehyde, aniline and acetophenone	6
7.	Preparation of benzenediazonium chloride and its application as azodye	6
8.	Identification of 1º, 2º, and 3º amines through the Hinsberg Test	6
9.	Aromatic Electrophilic Substitution reaction with a practically suitable example	6
10.	Preparation of Carbazole (Dibenzopyrrole)	6
List of virtual experiments		
1.	Acetylation of Salicylic acid	4
2.	Preparation of Tribromoaniline from Aniline	4
3.	Preparation of 1-Phenyl-3-methyl-5-pyrazolone	4

Reading references

1 B. S. Furniss. Vogel Textbook of Practical Organic Chemistry. Pearson Education. 2011,

2. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and Smith, P. W. G. Textbook of Practical 3. Organic Chemistry. Prentice-Hall. 1996, 5th Ed.

4. A. K. Nad and B Mahapatra. An Advanced Course in Practical Chemistry. New Central Book Agency. 2022, 3rd Ed.

5. V. K Ahluwalia and Sunita Dhingra. Practical Organic Chemistry. New Central Book Agency. 2017, 1st Ed.

6. N. K. Vishnoi. Advanced Practical Organic Chemistry. Vikas Publication. 2009, 3rd Ed.

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Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 105	**Course name:** Inorganic Chemistry II Laboratory

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
--	4/week	2	60	Lab	CCE & ESE	50	40

Course Description: This is a practical course of inorganic chemistry. This covers learning and analyzing the various group I and II. This course also deals preparation and estimation of coordination complexes of metals like Cu and Ni. This course also deals with determination of water of hydration in a given sample.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Identify the suitable reagent for group I and group elements.
CLO2: Understand the preparation and characterization of coordination complexes.
CLO3: Demonstrate the formation of Cu and Ni complexes
CLO4: Analyze the water of hydration in coordination compounds.

Detailed Practical

S. No.	Name of the Experiment	Hours
1.	Analysis and identification of group-I halides (potassium iodide, lithium chloride, and sodium chloride by flame test	5
2.	To analyze and identify the group-II halides (calcium chloride, strontium chloride, barium chloride	5
3.	Preparation of tetramine-copper (II) sulfate Complex and calculation of the yield from the stoichiometric equation.	5
4.	To Prepare hexamine nickel (II) chloride and calculate the yield from the stoichiometric equation	5
5.	To Determine the formula of an unknown hydrated sample	5
6.	To separate the given inorganic mixture using the filtration process	5
	Virtual Experiments	
7.	Determination of comparative strength of ionic and covalent bonds using a conductometer (https://www.slideshare.net/Qacey/investigatethe-properties-of-ionic-bond-and-covalent-bonthroughan-experiment)	10
8.	Practical demonstration type of bonding using solubility, melting point, and conductivity. (https://www.pasco.com/resources/video/3zJksoLtThA)	10

Reading references

1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Ed., Orient Longman, 1989.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, 5th Ed, Orient Longman, 1982.
3. Inorganic Chemistry: A Laboratory Manual by Mala Nath, 2016

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 106	**Course name:** Physical Chemistry-II Laboratory

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass (%)
-	4/week	2	60	Lab	CCE & ESE	50	40

Course Description: This course is a practical course in Physical Chemistry. Through this course, the students will get an insight into learning by performing hands-on experiments and practicals. From this course, they can understand and learn basic thermodynamic parameters like work done, enthalpy, entropy change, etc.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Identify the first law of thermodynamics
CLO2: Recognize the second law of thermodynamics
CLO3: Estimate property changes of mixing
CLO4: Evaluate Hess's law

Detailed Syllabus

S. No.	Experiment	Hours
1.	Demonstration of the first law of thermodynamics using simple household systems	6
2.	Determination of heat loss by the reactants in an exothermic reaction by calculating the heat gained by the products of that reaction.	6
3.	Experimental demonstration of the second law of thermodynamics with glow sticks	6
4.	Determination of the integral heats of dilution of H_2SO_4 starting with 10M acid and going down to 5M acid in the order 9M, 8M, 7M, 6M.	6
5.	Determination of heat loss by the reactants in an exothermic reaction by calculating the heat gained by the products of that reaction.	6
6.	Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide using a coffee mug calorimeter	6
7.	Investigation of the solubility of benzoic acid in water and determination of change in enthalpy.	6
8.	Determination of enthalpy of hydration of copper sulphate	6
9.	Experimental determination of ΔH values of two reactions using the technique of constant pressure calorimeter	6

List of virtual experiments

1.	Work done by the system and on the system
2.	Model of a heat engine
3.	Demonstration of adiabatic expansion – cloud in a bottle

Reading references

1. B. D. Kholsa, V. C. Garg, Senior Practical Physical Chemistry Delhi: R. Chand, 2018, 18th Edition
2. B. Viswanathan, P. S. Raghavan Practical Physical Chemistry Navi Mumbai Viva Books Private Limited 2017, 1st Edition
3. A. K. Nad, B. Mahapatra, A. Ghoshal. An Advanced Course in Practical Chemistry Paperback, l New Central Book Agency P LTD 2012, 3rd Edition
4. J. N. Gurtu and Amit Gurtu Advanced Physical Chemistry Experiments Pragati Prakashan 2008,

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 107	**Course name:** Semiconductor Devices

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing (%)
2	--	2	30	Lecture	ESE	50	40

Course Description: In this course, students will learn basics of the lattice vibrations, different theories to understand the physical properties of solids. This course will also be helpful to understand the concepts of semiconductor devices such as diodes and transistors which can help the students to apply the concepts in the real-life problems.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Remember the basic concept of different semiconducting devices.
CLO2: Understand the concept of phonons, diodes and transistors, and related fields.
CLO3: Examine the behavior of physical properties of solid materials.
CLO4: Analyze the concepts of diodes and transistors and apply them to real-life problems.

Detailed Syllabus

Units	Content	Hours
I	**Lattice Vibrations:** Elastic and atomic force constant, Brillioun zone, Dispersion relation, Dynamics of a chain of atoms, chain of two types of atoms, optical and acoustic modes, Phonons, Momentum of phonon, interaction of light with ionic crystals, inelastic collision of photon by phonon, Einstein's and Debye's theories of specific heat of solids, lattice heat capacity, density of modes, Debye approximation, examples	**15**
II	**Semiconductor Diodes & Transistors:** Drift of Carriers in Electric and Magnetic Fields, Principal and Application of Light Emitting Diode, Photodiode, Varactor Diode, Zener Diode, Tunnel Diode Illustrative examples and related problems. Characteristics of npn and pnp transistor, active and saturation region, common emitter, common base and common collector configuration, input and output characteristics, basics of field effect transistor (FET) and junction field effect transistor (JFET).	**15**

Reading references

Textbooks

1. R. K. Puri and V. K. Babbar. Solid State Physics. S. Chand & Co. Ltd. 2010.
2. V. K. Mehta. Principles of Electronics. S. Chand & Co. Ltd. 2014, 7th Ed.
3. A. Bieser. Concepts of Modern Physics. Tata McGraw-Hill. 2002, 6th Ed.

Reference books

7. Charles Kittel. Introduction to Solid State Physics. John Wiley & Sons. 2018, 8th Ed.
8. S. M. Sze and Kwok K. Ng. Physics of Semiconductor Devices. Wiley. 1996.
9. P. Bhattacharya. Semiconductor Opto-Electronic Devices. Prentice Hall. 1996. 2nd Ed.
10. M. K. Achuthan and K. N. Bhat. Fundamentals of Semiconductor Devices. McGraw Hill Education. 2007. 1st Ed.
11. J. Allison. Electronic Engineering Materials and Devices. McGraw Hill Education. 1990.

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 108	**Course name:** Semiconductor Devices Laboratory

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
-	4/week	2	60	Lab	CCE & ESE	50	40

Course Description: This is a practical course in physics that deals with the characteristics of different types of semiconductor devices. This course also explains the experimental learning of the semiconductor devices. This course will also help to understand and learn the designing of different electrical circuits.

Course Learning Outcome: At the end of this course students will be able to
CLO1: Record the change in current due to the change in voltage supply.
CLO2: Estimate the I-V characteristics of semiconductor devices such as diodes and transistors.
CLO3: Examine whether the provided semiconductor device is working or not by demonstrating the proper circuits.
CLO4: Design different types of electrical circuits such as in logic gates.

Detailed Syllabus

S. No.	**Experiment**	**Hours**
1.	Using Common Emitter Transistor Amplifier plot the Frequency response of a single PNP Transistor.	8
2.	To design the electrical circuit of different logic gates and verify the truth table for the same.	8
3.	(a) To determine the Hall voltage developed across the given material. (b) To calculate the Hall coefficient of the same material.	10
4.	To analyze the half wave and full wave rectifier output using a capacitor in shunt as a filter.	10
5.	Determine the figure of merit of a given Galvanometer.	8
6.	To verify Stefan's Law of Radiation (The law states that the amount of energy radiated through unit time from the surface of a black body is directly proportional to the fourth power of its absolute temperature).	8
7.	To determine the given high resistance by the Substitution method.	8

Reading reference

1. V. K. Mehta, Principles of Electronics, S. Chand & Co. Ltd., 2007
2. Kumar P. R. S., Practical Physics, PHI, 2011
3. Harnam Singh and P. S. Hemne, Practical Physics, S. Chand & Ltd., 2000.
4. S. K. Ghosh, Advanced Practical Physics, NCBA, 2010

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 109	**Course name:** Soft Skills

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Passing (%)**
2	--	2	30	Lecture	ESE	50	40

Course Description: In this course, students will be able to learn basics of the communication skills and SWOT analysis. This course will also be helpful for students in their goal-setting, self-analysis, and creative thinking. This course will also help to understand the corporate etiquette.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Remember the basics of communication skills and self-analysis.
CLO2: Understand the goal-setting and creative thinking.
CLO3: Observe the effective communications and presentation.
CLO4: Analyze the corporate etiquette.

Detailed Syllabus

Units	**Content**	**Hours**
I	SWOT Analysis • Who am I? • Factors influencing Self Perception • Self Esteem • Understanding positive and negative attitudes Goal Setting • Types of Goals: Immediate, Short term, Long term Strategies to Achieve Goals	15
II	Creativity • Out-of-box thinking • Lateral Thinking • Innovative Thinking Corporate Etiquettes • E-mail etiquette, Telephone etiquette, Dining etiquette, Office meeting etiquettes, Dress etiquette	15

Reading references

1. Jeff Butterfield, Soft Skills for Everyone by. Cengage publications. 2020, 2nd Ed.
2. Barun K Mitra. Personality Development and Soft Skills. Oxford University Press India. 2016, 2nd Ed.
3. Edward de Bono. Lateral Thinking: Creativity Step by Step. Harper Perennial. 2015, Reissue Ed.

Program: B. Sc. Chemistry	**Semester:** III
Course code: CH2 110	**Course name:** Laboratory Operations and Safety Measures

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
2	-	2	30	Lecture	CCE, ESE	50	20

Course Description: This course deals with understanding of various chemical operations in the laboratory. This course also explains the handling of chemicals and materials with proper guide and regulations. This course also delivers essential safety measures required in chemical laboratories.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand the safe working practices in a chemistry laboratory.
CLO2: Handle safely different glass apparatus.
CLO3: Analyze the chemicals and equipment safety in the laboratory.
CLO4: Apply protocols and methods for instruments in the laboratory.

Detailed Syllabus

Units	Content	Hours
I	**Laboratory Operations** Understanding of handling and use of common laboratory apparatus, various types of apparatus in labs such as glass apparatus, Plastic Apparatus, Metal Apparatus *etc.*, and Protocol of Cleaning and drying of glassware apparatus. Identification and set up of Apparatus assemblies and operational procedural protocols such as calibration of Volumetric/ Graduated Glassware Apparatus along with description, Knowledge and working protocol for various heating equipment in laboratory: Burners, Hot Plates, Heating Mantles, Muffle Furnace, Stirring apparatus in a laboratory: Use of Magnetic Stirrer and Mechanical Shaker, Heating and Cooling Bath. Various types of Filter Paper, Use of Analytical Balance: Mass and Weight, Use of melting point apparatus. assemblies of apparatus for distillation and refluxing, Assessment of distillation of inflammable solvents. Preparation of Chemical Laboratory Reagents.	**15**
II	**Safety Measures** Design a chart exhibiting of Do's and Don'ts instructions in a chemistry laboratory, Classification and labeling of the given set of chemicals, preparation of the indicative MSDS (Material Safety Data Sheet), Design of Common Safety Symbols along with its description. Identify and enlist the Incompatible Chemicals from a given set of chemicals, Describe procedure for the storage, maintenance and handling of compressed gas cylinders, Explore guidelines for the Storage of shelf chemicals and reagents, Carry out a detailed study of the Limits of Exposure of given Chemicals, Classify the Hazard based on storage, handling, and disposal of chemicals, procedural protocols for safe Disposal of Chemicals, Carry out investigations of the data regarding Institute Safety Policies: Safety Audits / Inspections.	**15**

Reading references

1. D. A. Skoog, D. M. West and F. J. Holler. Fundamentals of Analytical Chemistry. Saunders College Publishing. 1991, 2nd Ed.
2. J. Mendham. Vogels Textbook of Quantitative Chemical Analysis, Pearson Education. 2002, 6th Ed.
3. B. S. Furniss, A. J. Hannaford, Smith, W. G. Peter, A. R. Tatchell, Vogel's Text Book of Practical Organic Chemistry. Longman Scientific and Technical, Longman Group Ltd. 5th Ed. 1989.

Program: B. Sc. Chemistry	**Semester:** III
Course Code: CH2 111	**Course Name:** Indian Culture and Civilization

Lect.	**Practical (Hours)**	**Credits**	**Total Hours**	**Evaluation Scheme**			
				Component	**Exam**	**Max. Marks**	**Pass (%)**
2	-	2	30	Lecture	ESE	50	40

Course Description: The course on Indian Culture and Civilization will deliver in-depth knowledge regarding various aspects of Indian culture. The course also intends to understand the development of early civilizations in India. It will introduce the students to various dynasties that ruled over India. It will inspire students to appreciate, the literature, art, and architecture of ancient India.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand Indian culture and history.
CLO2: Describe Indian heritage and ethnicity.
CLO3: Explain Indian science, art, literature, and architecture.
CLO4: Analyze the underlying unity amidst diversity in all aspects of India's culture.

Detailed Syllabus

Units	**Content**	**Hours**
I	Characteristics of Indian culture, importance of Indian culture in one's life, variety in unity, secular outlook, universalism, Materialism and spiritualism, Ethics of Indians, Indian language, literature (an introduction of Vedic Samhitas and Upnishadas), painting, music, dance, drama, movies, Indian architecture (town planning of Indus valley civilization. Sculpture and Architecture of Indus valley civilization), India's contribution to global world heritage, through its culture civilization and diversity. Religion and Philosophy in Ancient and Medieval India, Religious Reforms in modern India, cultural history of Gujarat during ancient, medieval, and modern ages.	**15**
II	Surveys the rise of civilization and kingdoms on the Indian subcontinent from the first urban centers of the Indus Valley through the establishment of the Mughal Empire in the 16th century. Uses literary, archeological, linguistic, ethnological, and inscriptional evidence on the diversity of Indic peoples and their complex social, religious, and caste integration into the major states and empires of pre-modern India; considers wider civilizational networks and extensions of the Indian cultural sphere into other parts of Asia; integrates a historical and anthropological perspective on various primary materials.	**15**

Reading references

1. A. L. Basham. The Wonder That Was India. Vol - I. Rupa books New Delhi. 2004, 16th Ed.
2. Thaper Romila. A History of India Vol – I. Penguin India. 2000, 14th Ed.
3. D. D. Kosambi. The Culture and Civilization of Ancient India. Vikas Publishing House Pvt Ltd. 1997, 1st Ed.
4. D. D. Kosambi. An Introduction to the Study of Indian History. Sangam Books Ltd. 2023.
5. R. C. Majumdar. Ancient India. Motilal Banarsidass. 2017, 10th Ed.

B.Sc. Chemistry Semester IV
Detailed syllabus

Course Code	**CH2 201**
Course Name	**Organic Chemistry-IV**
L-T-P-C	**2-0-0-2**

Unit I	
Syllabus	**Hours**
Heterocyclic Compounds Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid. **Alkaloids** Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine	**15**

Unit II	
Syllabus	**Hours**
Terpenes Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol. **Drugs & Pharmaceuticals** Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).	**15**

Reading references

1. Organic Chemistry – Volume-I & II – I.L. Finar
2. Heterocycles – R.K. Bansal
3. An introduction to chemistry of heterocyclic compounds – R.M. Acheson
4. An introduction to chemistry of terpenoids and steroids – William Templeton
5. The alkaloids – Kenneth Walter Bentley

Course Code:	**CH2 202**
Course Name:	**Inorganic Chemistry-III**
L-T-P-C	**2-0-0-2**

Unit I	
Syllabus	**Hours**
Periodicity of Elements: s, p, d, f-block elements, the long form of the periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in the periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, and group electronegativity.	**15**

Unit II	
Syllabus	**Hours**
Chemistry of s and p Block Elements: Inert pair effect, Relative stability of different oxidation states, diagonal relationship, and anomalous behavior of the first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent, and interstitial. Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties, and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides, and oxoacids of nitrogen, phosphorus, and chlorine. Peroxo acids of sulfur, interhalogen compounds, polyhalide ions, pseudo halogens, and basic properties of halogens.	**15**

Reading references

1. R. L. Madan. Chemistry for Degree Students. S. Chand Publications. 2016, 1st Ed.
2. R. Sarkar. General and Inorganic Chemistry. New Central Book Agency. 2011, 3rd Ed.
3. J. D. lee. Concise Inorganic chemistry. Oxford University Press. 2008, 5th Ed.
4. F. A. Cotton, G. Wilkinson, Paul. L. Gaus. Basic Inorganic Chemistry. Wiley. 2007 3rd Ed.
5. N. N. Greenwood and A. Earnshaw. Chemistry of the elements. Pergamon Press 1989.

Course Code:	**CH2 203**
Course Name:	**Physical Chemistry-III**
L-T-P-C	**2-0-0-2**

Unit I	
Syllabus	**Hours**
Ionic equilibrium: Strong, moderate, and weak electrolytes, degree of ionization, factors affecting the degree of ionization, ionization constant, and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis, Buffer solutions; Henderson equation and its applications; buffer capacity, buffer range, buffer action Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Theory of acid-base indicators; selection of indicators and their limitations. **Chemical equilibrium:** Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. A coupling of exoergic and endoergic reactions.	15

Unit II	
Syllabus	**Hours**
Equilibrium constants and their quantitative dependence on temperature, pressure, and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c, and K_x. Le Chatelier principle. **Chemical kinetics:** Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated forms of rate expressions up to second-order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates.	15

Reading references

Textbooks

1. R. L. Madan. Chemistry for Degree Students. S. Chand Publications. 2016, 1st Ed.
2. B. R. Puri. Principles of Physical Chemistry. Jalandhar Vishal Publishing Co. 2020, 49th Ed.
3. G. W. Castellan. Physical Chemistry. Narosa Publication. 3rd Ed.
4. Raj, Gurdeep, Meerut Advanced Physical Chemistry, Raj, Gurdeep, Meerut: Krishna Prakashan, 2018 4th Edition
5. B. R. Puri. Sharma. Principles of Physical Chemistry, L. R., Vishal Publishing CO. Delhi: 2018, 4th Edition
6. Physical Chemistry, Puri, B. R., Sharma, L. R., Vishal Publishing CO. Delhi: 2018.

Reference books

8. P.L. Soni. Textbook of Physical Chemistry. Sultan Chand New Delhi. 2016.
9. C. Kittel. Introduction to Solid State Physics. John Wiley & Sons. 2004, 8th Ed.
10. Prutton and Marron. Principles of physical chemistry. CBS PUBLISHERS AND DISTRIBUTORS PVT LTD. 2017. 4th Ed.
11. Soni and Dharmahara. Text Book of Physical Chemistry. Sultan Chand & Sons. 2011.
12. B. R. Puri and L. R. Sharma. Text Book of Physical Chemistry. Vishal Publishing. 2020, 1st Ed.
13. K. L. Kapoor. Text Book of Physical Chemistry. Macmillan. 2010, Volume 6.

Course Code:	**CH2 204**	
Course Name:	**Organic Chemistry-III Laboratory**	
L-T-P-C	**0-0-4-2**	
S. No.	**List of Experiments to be Conducted**	**Hours**
1.		6
2.		6
3.		6
4.		6
5.		6
6.		6
7.		6
8.		6
9.		6
10.		6
List of virtual experiments		
1.		4
2.		4
3.		4

Reading references

1. B. S. Furniss. Vogel Textbook of Practical Organic Chemistry. Pearson Education. 2011,
2. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and Smith, P. W. G. Textbook of Practical 3. Organic Chemistry. Prentice-Hall. 1996, 5th Ed.
4. A. K. Nad and B Mahapatra. An Advanced Course in Practical Chemistry. New Central Book Agency. 2022, 3rd Ed.
5. V. K Ahluwalia and Sunita Dhingra. Practical Organic Chemistry. New Central Book Agency. 2017, 1st Ed.
6. N. K. Vishnoi. Advanced Practical Organic Chemistry. Vikas Publication. 2009, 3rd Ed.

Course Code:	**CH2 205**	
Course Name:	**Inorganic Chemistry-II Laboratory**	
L-T-P-C	**0-0-4-2**	
S. No.	**List of Experiments to be Conducted**	**Hours**
1.	To determine the water of crystallization of a given salt. $BaCl_2$ $2H_2O$, $Mg.SO_4$ $7H_2O$	8
2.	To determine the Percentage of Purity of a given salt (Na_2CO_3, $NaHCO_3$)	8
3.	To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry	8
4.	To determine the exchange capacity of cation exchange resins and anion exchange resins.	8
5.	To separate the amino acids from organic acids by ion exchange chromatography.	8
6.	To separate metal ions from their binary mixture.	8
List of virtual experiments		
1.	Describe the difference between coefficients and subscripts in a chemical equation.	4
2.	Describe ambidentate ligand and chelating ligand	4
3.	Practical demonstration of different types of chromatographic separation.	4

Reading references

1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn, Orient Longman, 1989.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, 5th Edn, Orient Longman, 1982.
3. Inorganic Chemistry: A Laboratory Manual Hardcover – Import, 30 June 2016 by Mala Nath

Course Code:	**CH2 206**	
Course Name:	**Physical Chemistry-III Laboratory**	
L-T-P-C	**0-0-4-2**	
S. No.	**List of experiments to be conducted**	**Hours**
1.	Preparation of buffer solutions of different pH a. Sodium acetate-acetic acid b. Ammonium chloride-ammonium hydroxide	4
2.	pH-metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.	8
3.	Determination of dissociation constant of a weak acid.	8
4.	Study of the shift in equilibrium in the reaction of ferric and thiocyanate ions.	8
5.	Validation of the Le Chatelier Principle using simple laboratory methods	8
6.	Determination of order by initial rate method: Iodide-persulphate reaction	8
7.	Compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of methylacetate.	8
8.	Determine the rate constant for the inversion of sucrose using a polarimeter	8
List of virtual experiments		
1. pKa determination by half-neutralization method (https://www.youtube.com/watch?v=IjMHbN3BdBs)		

Reading references

1. B. D. Khosla, V. C. Garg, Adarsh Gulati. Senior Practical Physical Chemistry. R. Chand. 2018.
2. B. Viswanathan and P. S. Raghavan. Practical Physical Chemistry. Navi Mumbai Viva Books Private Limited. 2017.
3. A. K. Nad, B. Mahapatra, A. Ghoshal. An Advanced Course in Practical Chemistry. Paperback, New Central Book Agency P LTD. 2022.
4. B. Vishwanathan, P. S. Raghavan. Practical Physical Chemistry. Viva Publisher. 2012.

Course Code:	**CH2 207**
Course Name:	**Applications of Semiconductors**
L-T-P-C	**2-0-0-2**

Unit I	
Syllabus	**Hours**
Photonic Device Radiative and non radiative transitions, optical absorption, diode photodetectors, solar cell, LED, diode laser, optical gain and threshold current for lasing, Fabry-Perrot cavity length for lasing, and the separation	**15**

Unit II	
Syllabus	**Hours**
Memory Devices Static and Dynamic Random Access memories (SRAM and DRAM), CMOS and NMOS, nonvolatile – NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD)	**15**

5. J. N. Gurtu and Amit Gurtu. Advanced Physical Chemistry Experiments. Pragati Prakashan. 2011.

Reading references

Textbooks

1. R. K. Puri and V. K. Babbar. Solid State Physics. S. Chand & Co. Ltd. 2010.
2. V. K. Mehta. Principles of Electronics. S. Chand & Co. Ltd. 2014, 7th Ed.
3. A. Bieser. Concepts of Modern Physics. Tata McGraw-Hill. 2002, 6th Ed.

Reference books

1. R. K. Hair and S. L. Gupta**.** Engineering Physics. Dhanpat Rai. 2012.
2. Charles Kittel. Introduction to Solid State Physics. John Wiley & Sons. 2018, 8th Ed.
3. S. M. Sze and Kwok K. Ng. Physics of Semiconductor Devices. Wiley. 1996.
4. P. Bhattacharya. Semiconductor Opto-Electronic Devices. Prentice Hall. 1996. 2nd Ed.
5. M. K. Achuthan and K. N. Bhat. Fundamentals of Semiconductor Devices. McGraw Hill Education. 2007. 1st Ed.
6. J. Allison. Electronic Engineering Materials and Devices. McGraw Hill Education. 1990.

Course Code:	**CH2 208**	
Course Name:	**Applications of Semiconductors Laboratory**	
L-T-P-C	**0-0-4-2**	
S. No.	**List of experiments to be conducted**	**Hours**
1.	Numerical aperture of a fiber	8
2.	Fabry-Perrot interferometer	8
3.	Michelson's interferometer	8
4.	Laser characteristics	8
5.	Characteristics of a solar cell	8
6.	LED Characteristics	8
List of virtual experiments		

Reference books

1. V. K. Mehta, Principles of Electronics, S. Chand & Co. Ltd., 2007
2. Kumar P. R. S., Practical Physics, PHI, 2011
3. Harnam Singh and P. S. Hemne, Practical Physics, S. Chand & Ltd., 2000.
4. S. K. Ghosh, Advanced Practical Physics, NCBA, 2010

Course Code:	CH2 209
Course Name:	Professional Communications
L-T-P-C	2-0-0-2

Unit I	
Syllabus	**Hours**
• Oral communications • Written communications • Foundation of creative expressions • Interpersonal communications	**15**

Unit II	
Syllabus	**Hours**
• Skill enhancement • Personality grooming • Role play practice	**15**

Reading references

Textbooks

1. Jeff Butterfield, Soft Skills for Everyone by. Cengage publications. 2020, 2nd Ed.

Reference books

1. Barun K Mitra. Personality Development and Soft Skills. Oxford University Press India. 2016, 2nd Ed.
2. Edward de Bono. Lateral Thinking: Creativity Step by Step. Harper Perennial. 2015, Reissue Ed.

Course Code:	CH2 210
Course Name:	Software for Scientific Learning
L-T-P-C	2-0-0-2

Unit I	
Syllabus	**Hours**
Chem Draw: Chemical structure drawing, Name-to-Structure, Structure-to-Name, Realistic 3D conformation of molecules, 1H and 13C NMR predictions, and integrations to scientific literature databases. Access safety data from regulatory agencies, and find chemical suppliers. Biochemical drawings. *Chem Craft:* Chemical structure drawing of various molecules. *EndNote:* Techniques of scientific literature management.	**15**

Unit II	
Syllabus	**Hours**
Origin: Drawing of scientific graphs using data files in various formats such as ASCII text, Excel, etc. Exports of graphs to various image file formats such as JPEG, PNG, GIF, EPS, TIFF, etc. *Adobe Illustrator/Photoshop:* Draw and edit scientific graphs and images. *Gauss view:* Making a graphical interface to build molecules, Set up calculations, and analyze the results.	**15**

Reading references

1. ChemDraw 21.0 User Guide. PerkinElmer
2. ChemDraw 17.0 User Guide. PerkinElmer
3. Prof. Dr. Stefan Bienz. Short Manual to the Chemical Drawing Program ChemDraw®. University of Zurich.
4. EndNote: a Beginner's Guide. Library Subject Guide. RMT University.

Course Code:	**CH2 211**
Course Name:	**Renewable Energy**
L-T-P-C	**2-0-0-2**

Unit I	
Syllabus	**Hours**
Fossil fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, their limitation, need for renewable energy, and nonconventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, and Hydroelectricity.	**15**
Unit II	
Syllabus	**Hours**
Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of the solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar greenhouses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun-tracking systems.	**15**
Unit III	
Syllabus	**Hours**
Wind and hydro Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, grid interconnection topologies, Hydropower resources, hydropower technologies, the environmental impact of hydropower sources.	**10**

Reading references

1. B.H. Khan. Non-conventional energy sources. McGraw Hill Education India Private Limited. 2017, 3rd Ed.
2. Suhas P Sukhative. Solar energy. Tata McGraw - Hill Publishing Company Ltd. 2017 4th Ed.
3. Godfrey Boyle. Renewable Energy, Power for a sustainable future. Oxford University Press. 2012, 3rd Ed.

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