

KUMAUN UNIVERSITY NAINITAL



Common Minimum Syllabus for State Universities and Colleges of
Uttarakhand

National Education Policy- 2020

Subject: Chemistry

PROPOSED STRUCTURE OF UG CHEMISTRY SYLLABUS

Effective from academic year 2022-2023

National Education Policy-2020

Common Minimum Syllabus for all Uttarakhand State Universities/ Colleges

SUBJECT: CHEMISTRY

Syllabus Developed by		
Name	Designation	Affiliation
Dr. Chitra Pande	Professor & Head	D. S. B. Campus, Kumaun University, Nainital
Dr. Pushpa Joshi	Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. N. G. Sahoo	Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Geeta Tewari	Associate Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Shah Raj Ali	Associate Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Suhel Javed	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Mahesh. C. Arya	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Manoj Dhuni	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Penny Joshi	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. A. B. Melkani	Retired Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. A. Dandapat	Inspire Faculty	D. S. B. Campus, Kumaun University, Nainital
Assistance in typing and formatting from contractual faculty Dr. Lalit Mohan, Dr. Girish Kharkwal, Dr. Deepshikha Joshi and Miss. Anchal Aneja is appreciated		

24/5/2023

PROPOSED STRUCTURE FOR UG AND PG COURSES UNDER NATIONAL EDUCATION POLICY - 2020 FOR THE STATE OF UTTARAKHAND IN ACCORDANCE WITH GUIDELINES ISSUED VIDE G.O. NUMBER 1196/XXIV-C-4/2021-01/06/2019 DATED 08TH OCTOBER 2021

Year	Sem.	Subject I	Subject II	Subject III	Subject IV	Vocational	Co-Curricular	Industrial Training/ Survey/ Research Project	{Minimum Credits} For the year	{Cumulative Minimum Credits} Required for Award of Certificate/ Diploma/ Degree
		Major	Major	Major	Minor Elective	Minor	Minor	Major		
		4/5/6 Credits	4/5/6 Credits	4/5/6 Credits	4/5/6 Credits	3 Credits		4 Credits		
		Own Faculty	Own Faculty	Own/ Other Faculty	Other Subject/ Faculty	Vocational/ Skill Development Course	Co-Curricular Course (Qualifying)	Inter/Intra Faculty related to main Subject		
1	I	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	1 (4/5/6)	1	1		46	{46} Certificate in Faculty
	II	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)		1	1			
2	III	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	1 (4/5/6)	1	1		46	{92} Diploma in Faculty
	IV	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)	Th-1(6) or Th-1(4)+ Pract-1(2)		1	1			
3	V	Th-2(5) or Th-2(4)+ Pract-1(2)	Th-2(5) or Th-2(4)+ Pract-1(2)				1	1 (Qualifying)	40	{132} Bachelor in Faculty
	VI	Th-2(5) or Th-2(4)+ Pract-1(2)	Th-2(5) or Th-2(4)+ Pract-1(2)				1	1 (Qualifying)		
4	VII	Th-4(5) or Th-4(4)+ Pract-1(4)			1 (4/5/6)			1 (4)	52	{184} Bachelor (Research) in Faculty
	VIII	Th-4(5) or Th-4(4)+ Pract-1(4)						1 (4)		
5	IX	Th-4(5) or Th-4(4)+ Pract-1(4)						1 (4)	48	{232} Master in Faculty
	X	Th-4(5) or Th-4(4)+ Pract-1(4)						1 (4)		
6	XI	2 (6)	1 Research (4) Methodology					1 (Qualifying)	16	{248} PGDR in Subject
6,7,8	XII-XVI							Ph. D. Thesis		Ph.D. in Subject

24/5/2023

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Semester-wise Titles of the Papers in B.Sc. Chemistry

Major/Core courses

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Introductory Chemistry					
1	I	Core	Fundamentals of Chemistry-I	Theory	4
		Core	Chemical Analysis-I	Practical-1	2
	II	Core	Fundamentals of Chemistry-II	Theory	4
		Core	Chemical Analysis-II	Practical-1	2
Diploma in Chemical Science					
2	III	Core	General Chemistry-I	Theory	4
		Core	Analytical Procedures-I	Practical-2	2
	IV	Core	General Chemistry-II	Theory	4
		Core	Analytical Procedures-II	Practical-2	2
Degree in Bachelor of Science					
3	V	Core	Inorganic Chemistry	Theory	4
		Core	Organic Chemistry	Theory	4
		Core	Analytical Procedures -III	Practical-3	2
			Research Project	Project	Qualifying
	VI	Core	Physical Chemistry	Theory	4
		Core	Analytical Chemistry	Theory	4
		Core	Analytical Procedures -IV	Practical-3	2
			Research Project	Project	Qualifying

Minor/Elective courses

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
1	I/II		Basics of Chemistry I	Theory	4
2	III/IV		Basics of Chemistry II	Theory	4

Skill Enhancement/Vocational Courses

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
1	I		Basics of Analytical Chemistry-I	Theory	3
	II		Basics of Analytical Chemistry-II	Theory	3
2	III		Essential Oils for Wellness	Theory	3
	IV		Chemistry of Skincare Products	Theory	3

Purpose of the Program

The Importance of chemistry arises because so many other disciplines draw on certain chemical principles and concepts. The purpose of the undergraduate chemistry program at the university and college level is to prepare our students for all those fields where basic knowledge of chemistry is required including academia for careers as professionals in various industries and research institutions.

Program Outcomes

- PO 1.** Students will have a firm foundation in the fundamentals and applications of chemical and scientific theories including those in analytical, inorganic, organic and physical chemistry.
- PO 2.** Students will be able to design and carry out scientific experiments as well as accurately record and analyze the data of such experiments.
- PO 3.** Students will develop skill in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- PO 4.** Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- PO 5.** Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
- PO 6.** Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
- PO 7.** Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
CERTIFICATE IN INTRODUCTORY CHEMISTRY	
First Year	Certificate in Introductory Chemistry will give the student a basic knowledge of all the fundamental principles of chemistry like atomic structure, molecular polarity, bonding theories of different molecules, resonance concept, hyperconjugation, field effects, periodic properties of more than 111 elements, mechanism of organic reactions, stereochemistry, detailed study of states of matter including kinetic theories of gases, solid and liquid states, chemistry of aliphatic and aromatic compounds, chemical kinetics, its scope and first law of thermodynamics. Student will be able to understand the qualitative and quantitative chemical analysis of the compounds in the laboratory. This certificate

	course is definitely going to prepare the students for various fields of chemistry and will give an insight into all the branches of chemistry. It will enable students to join the diploma course (semester III and IV) in any University or College of Higher education in Uttarakhand
Second Year	DIPLOMA IN CHEMICAL SCIENCE
	Diploma in Chemical Science will provide the theoretical as well as practical knowledge of handling chemicals, apparatus, equipment and instruments. The knowledge about second law of thermodynamics, chemical equilibrium, phase equilibrium, electrochemistry, coordination chemistry, acid-base theories, chemistry of transition elements, halides, alcohols, phenols, aldehydes, ketones and carboxylic acids will enable the students to work as chemists in various industries. The experimental work during the diploma course will enhance the skill of the students regarding chemical and physical tests of inorganic as well as organic compounds along with some physical experiments which will be beneficial to achieve their goals in industrial sectors. It will enable students to join the Bachelor of Science course (semester V and VI) in any University or College of Higher education in Uttarakhand
Third Year	DEGREE IN BACHELOR OF SCIENCE
	Degree in Bachelor of Science programme aims to introduce very important aspects of modern-day course curriculum, namely, chemistry of nitrogen containing compounds, organometallic, lipids, fats, dyes, , reagents in organic synthesis, carbohydrates, proteins, biomolecules, data analysis, nano-chemistry, green chemistry, stability of coordination compounds, cement, ceramics, glass, inorganic fertilizers, radioactivity, magnetic behavior, transition metal complexes, surface chemistry, quantum mechanics, solutions, third law of thermodynamics, photochemistry, and spectroscopic techniques. This knowledge will make the students skilled to work in various chemical industries like cement industries, agro product, rubber industries, food processing industries, fertilizer industries etc. It will also enable the students to understand the importance of the biomolecules in biological science and related fields. Upon completion of a degree, chemistry students will be able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments. It will help a candidate to succeed at an entry-level position in chemical industry or a chemistry postgraduate program.

Subject: Chemistry									
Year	Semester	Theory Paper	Units	Practical Paper	Units	Elective (Minor) Course	Vocational (Skill Enhancement) Course	Research Project	Total Credits of the Year subject
1	I	Fundamentals of Chemistry-I	1. Atomic Structure and Periodic Properties 2. Chemical Bonding-I 3. Mechanism of Organic Reactions 4. Stereochemistry of Organic Compounds 5. States of Matter-I 6. States of Matter-II	Chemical Analysis-I	1. Laboratory hazards and safety precautions 2. Inorganic exercise 3. Organic exercise 4. Physical exercise	Basics of Chemistry I	Basics of Analytical Chemistry-I	NIL	22
	II	Fundamentals of Chemistry-II	1. Chemical Bonding-II 2. Salient Features of s- and p-Block Elements 3. Aliphatic Compounds 4. Aromatic Compounds 5. Chemical Kinetics and Catalysis 6. Thermodynamics I	Chemical Analysis-II	1. Laboratory hazards and safety precautions 2. Inorganic exercise 3. Organic exercise 4. Physical exercise		Basics of Analytical Chemistry-II	NIL	
2	III	General Chemistry-I	1. Chemistry of Transition Elements (First, second and third Transition Series)	Analytical Procedures-I	1. Laboratory hazards and safety precautions 2. Inorganic exercise 3. Organic exercise		Basics of Analytical Chem	NIL	22

			2. Coordination Chemistry-I 3. Halides 4. Alcohols and Phenols 5. Thermodynamics II 6. Chemical Equilibrium, Phase Equilibrium		4. Physical exercise	Basics of Chemistry II	istry-III		
	IV	General Chemistry-II	1. Acids and Bases 2. Chemistry of Inner Transition Elements 3. Aldehydes and Ketones 4. Carboxylic Acids 5. Electrochemistry I 6. Electrochemistry II	Analytical Procedures-II	1. Laboratory hazards and safety precautions 2. Inorganic exercise 3. Organic exercise 4. Physical exercise		Basics of Analytical Chemistry-IV	NIL	
3	V	Inorganic Chemistry	1. Metal-Ligand Bonding in Transition Metal Complexes 2. Thermodynamic and Kinetic Aspects of Coordination Compounds 3. Electronic Spectra of Transition Metal Complexes 4. Magnetic Properties of Transition Metal Complexes 5. Organometallic Chemistry 6. Some Industrially Important Inorganic	Analytical Procedures - III	1. Laboratory hazards and safety precautions 2. Inorganic exercise 3. Organic exercise			Research Project (Qualifying)	4+4+2=10

			Materials						
		Organic Chemistry	1. Lipids and Fats 2. Reagents in Organic Synthesis 3. Nitrogen containing organic Compounds 4. Organometallic Compounds 5. Dyes 6. Carbohydrates and Proteins						
	VI	Physical Chemistry	1. Surface Chemistry 2. Elementary Quantum Mechanics 3. Photochemistry 4. Solutions and Colligative Properties 5. Thermodynamics III 6. Radiochemistry	Analytical Procedures - IV	1. Laboratory hazards and safety precautions 2. Physical exercise 3. Organic exercise 4. Chromatographic technique 5. Inorganic exercise			Research Project (Qualifying)	4+4+2=10
		Analytical Chemistry	1. General Biochemistry 2. Data Analysis 3. Fundamentals of Nanochemistry 4. Basics of Green Chemistry 5. Analytical Techniques 6. Spectroscopy						

Subject: Chemistry							
Course	Semester	Paper Title		Prerequisite for Paper	Elective for Major Subject	Hours per Semester	Total Credits of the Year subject
Certificate in Introductory Chemistry	I	Theory-1	Fundamentals of Chemistry-I	Chemistry of 12 th standard	Yes open for all	60	4
		Practical-1	Chemical Analysis-I	Chemistry of 12 th standard	Yes open for all	60	2
		Skill enhancement	Basics of Analytical Chemistry-I	Chemistry of 12 th standard	Yes open for all	60	3
	II	Theory-1	Fundamentals of Chemistry-II	Passed Sem-I Theory paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-1	Chemical Analysis-II	Opted Sem-II Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Skill enhancement	Basics of Analytical Chemistry-II	Chemistry of 12 th standard	Yes open for all	60	3
	I/II	Elective/Minor	Basics of Chemistry I	Chemistry of 12 th standard	Yes open for all	60	4
Diploma in Chemical Science	III	Theory-1	General Chemistry-I	Passed Certificate Course in Introductory Chemistry	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-2	Analytical Procedures-I	Opted Sem-III Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Skill enhancement	Basics of Analytical Chemistry-III	Chemistry of 12 th standard	Yes open for all	60	3
	IV	Theory-1	General Chemistry-II	Passed Sem-III Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-2	Analytical Procedures-II	Opted Sem-IV Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Skill enhancement	Basics of Analytical Chemistry-IV	Chemistry of 12 th standard	Yes open for all	60	3
	III/IV	Elective/Minor	Basics of Chemistry II	Chemistry of 12 th standard	Yes open for all	60	4

Degree in Bachelor of Science	V	Theory-1	Inorganic Chemistry	Passed Sem-III and Sem-IV Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Theory-2	Organic Chemistry	Passed Sem-III and Sem-IV Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-3	Analytical Procedures-III	Opted Sem-V Theory Paper-1 &2.	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Research Project				60	Qualifying
	VI	Theory-1	Physical Chemistry	Passed Sem-V Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Theory-2	Analytical Chemistry	Passed Sem-V Theory papers Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-3	Analytical Procedures-IV	Opted Sem-VI Theory Paper-1 &2	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Research Project				60	Qualifying

Pattern of examination theory papers

A. Theory paper (MM: 75)

Each theory paper shall consist two sections A and B.

Section A: *(Short answers type with reasoning); **Thirty (30) marks**, eight questions of **six (6) marks** each, any five have to be attempted.*

Section B: *(Long answers type): **Forty-five (45) marks**, five questions of **fifteen (15) marks** each, any three have to be attempted.*

B. Internal assessment (MM: 25)

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.

C. Practical: MM: 100 (75: External + 25: Internal)

*The laboratory work of the students has to be evaluated periodically. The internal assessment (in the form of lab test, lab record, internal evaluation, assignment/home assignment and attendance) of total **13 marks** for each semester shall be conducted during the semester. A minimum of 12 experiments covering all kinds of exercises have to be conducted during a semester. Maximum **12 marks** of attendance can be given to the students. In each semester practical examination of **75 marks** has to be conducted by two examiners (External and internal) having duration of **4 hours for I to IV Semester** and **5 hours for V and VI Semester**. The total number of students to be examined per batch should not be more than sixty. Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital.*

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Introductory Chemistry					
1	I		Fundamentals of Chemistry-I	Theory	4
			Chemical Analysis-I	Practical	2
1	II		Fundamentals of Chemistry-II	Theory	4
			Chemical Analysis-II	Practical	2

**Semester-I
Paper-I (Theory)**

Course Title: Fundamentals of Chemistry-I

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

Course outcomes: There is nothing more fundamental to chemistry than the chemical bond. Chemical bonding is the language of logic for chemists. Chemical bonding enables scientists to take the 100-plus elements of the periodic table and combine them in myriad ways to form chemical compounds and materials. Periodic trends, arising from the arrangement of the periodic table, provide chemists with an invaluable tool to quickly predict an element's properties. These trends exist because of the similar atomic structure of the elements within their respective group families or periods, and because of the periodic nature of the elements. Reaction mechanism gives the fundamental knowledge of carrying out an organic reaction in a step-by-step manner. This course will provide a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Students will gain an understanding of;

- ✓ Molecular geometries, physical and chemical properties of the molecules.
- ✓ Current bonding models for simple inorganic and organic molecules in order to predict structures and important bonding parameters.
- ✓ This course gives a broader theoretical picture in multiple stages in an overall chemical reaction.
 - ✓ It describes reactive intermediates, transition states and states of all the bonds broken and formed.
- ✓ It enables to understand the reactants, catalyst, stereochemistry and major and minor products of any organic reaction. It describes the types of reactions and the kinetic and thermodynamic aspects one should know for carrying out any reaction and the ways how the reaction mechanism can be determined.
- ✓ The chapter stereochemistry gives the clear picture of two-dimensional and three-dimensional structure of the molecules, and their role in reaction mechanism.
- ✓ The course will help the students to explain the existence of different states of matter in terms of balance between intermolecular forces and thermal energy of particles; explain the laws

governing the behaviour of ideal gases; apply the gas laws in various real-life situations. In general, the course will also strengthen the knowledge of students regarding complete picture of states of matter that includes gaseous, liquid, solid and colloidal states.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Content	Number of Hours
1	Atomic Structure and Periodic Properties: Dual nature of matter; de Broglie concept. Heisenberg uncertainty principle; its significance. Atomic orbitals, Schrödinger wave equation (no derivation); significance of wave function. Quantum numbers, shapes of s, p and d orbitals. Aufbau energy diagram, Pauli's exclusion principle. Hund's rule of maximum multiplicity. Electronic configuration of elements (s block, p block and first series of d-block elements). Effective nuclear charge, Slater's rule. The general idea of Modern periodic table, atomic and ionic radii, ionization potential, electron affinity, electronegativity-definition, trends of variation in periodic table and their application in prediction and explaining the chemical behavior of elements and compounds thereof.	12
2	Chemical Bonding-I: Valence Shell Electron Pair Repulsion Theory (VSEPR) and shapes of NH ₃ , H ₂ O, H ₃ O ⁺ , SF ₄ , ClF ₃ , XeF ₂ , XeOF ₂ , XeOF ₄ , XeO ₃ , XeF ₄). Valence Bond Theory and its limitations; various types of hybridization and shapes of different inorganic and organic molecules (CH ₄ , C ₂ H ₂ , C ₂ H ₄ , CO ₂ , SO ₂ , NO ₃ ⁻ , BCl ₃ , SF ₆ , BeCl ₂ , PCl ₅ , IF ₇).	8
3	Mechanism of Organic Reactions: Types of reagents-electrophiles and nucleophiles. Resonance, hyperconjugation, field effects- inductive, mesomeric, electromeric effect. Types of organic reactions: Substitution. Addition, rearrangement, elimination. Energy considerations. Reactive intermediates-carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples).	8
4	Stereochemistry of Organic Compounds: Types of isomerism-optical isomerism- elements of symmetry, molecular chirality, enantiomers, stereogenic centers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centre, diastereomers, threo and erythro diastereomers, meso compounds, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: determination of	12

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

Books Recommended:

- i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
- ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
- iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
- viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994, 1st edition.
- ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.

- x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
- xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
- xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
- xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
- xvii. Bariyar, A., Singh, R.P. and Dwivedi, A., "Text Book for B. Sc. Chemistry I", Anu Books, 2019.

Suggested online links:

1. <https://www.youtube.com/watch?v=ZeV3V0DjupQ&list=PLmxSS9XYst219YI3DjJUP52APmR9bea1Y>
2. https://www.youtube.com/watch?v=q-P79gnqNR8&list=PLmUlqVgZsTVVRvO3R8g-x12EMc5vmcq_c
3. <https://www.youtube.com/watch?v=gahQYHs0c8s>
4. https://www.youtube.com/watch?v=w2He_Q0Mf0c
5. <https://www.youtube.com/watch?v=q1qMFCZVlPk>
6. <https://www.youtube.com/watch?v=nWTgMr6idf0>
7. <https://www.youtube.com/watch?v=JNLJyhqXaTc&t=10s>
8. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
9. https://onlinecourses.nptel.ac.in/noc22_cy36/preview
10. https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12th standard.

Suggested equivalent online courses:

Further Suggestions:

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

Programme/Class: Certificate in Introductory Chemistry	Year: First	Semester: First
Paper-2 Practical Subject: Chemistry		
Course Code:	Course Title: Chemical Analysis-I	

Course outcomes:

Upon completion of this course, the students will have the knowledge and skills to: understand the laboratory methods and tests related to volumetric analysis and estimation of surface tension of commercial products. Also, they can understand the systematic analysis of organic compounds. The students will be able to

- ✓ Determine the strength of unknown solution by titration.
- ✓ Determine the relative surface tension of a given liquid.
- ✓ Analyze and identify the unknown organic compound.

Credits:2	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Inorganic Exercise: Acid-base titrations; preparation of a solution in normal/molar terms, its standardization using a primary standard solution, determination of the strength of unknown solution. For example preparation of NaOH solution (secondary standard say N/10), preparation of (COOH) ₂ solution (primary standard say N/10), standardization of NaOH solution titrating it against (COOH) ₂ solution using phenolphthalein (indicator) and then determination of the strength of given HCl solution.	18
3	Organic exercise: Using Molecular Models : , chiral and achiral molecules Determination of Relative and Absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: Using Molecular Models determination of configuration of geometrical isomers, E & Z system of nomenclature.	18
4	Physical exercise: Determination of relative surface tension of the given liquid using	18

	Stalagmometer.	
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Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12th standard.

Suggested equivalent online courses:

Further Suggestions:

One exercise each from Acid-base titrations, organic exercise (one organic compound) and physical exercise (relative surface tension) shall be given in the examination.

Distribution of marks shall be as given below:

1. Inorganic exercise	25
2. Organic exercise	20
3. Physical exercise	20
4. Viva	10
5. Home assignment/internal assessment, lab record and attendance	25

Note:

- The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester lab record has to be maintained by the department/college as an official record.
- Less than zero mark will not be awarded.
- The total number of students to be examined per batch shall not be more than sixty.
- Duration of the practical examination shall be of **04 (four) hours**.
- Marks obtained in the practical examination have to be submitted to the Head of the department/Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital

Suggested Readings:

- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

Suggestive digital platforms web links:

- <http://chemcollective.org/vlabs>
- <https://www.vlab.co.in/broad-area-chemical-sciences>
- <https://wp.labster.com/chemistry-virtual-labs/>

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

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

Course outcomes: Upon successful completion of this course, the students will be able to describe the reactions shown by aliphatic and aromatic compounds. They will also be able to understand the bonding in inorganic molecules, salient features of s- and p- block elements, different aspects of chemical kinetics, catalysis and first law of thermodynamics.

Credits: 4		Compulsory
Max. Marks: 25+75		Min. Passing Marks:.....
Total Number of Hours = 60		
Units	Content	Number of Hours
1	Chemical Bonding-II: Molecular Orbital Theory (MOT) as applied to diatomic homonuclear/heteronuclear inorganic molecules. MO diagrams and bond order of H ₂ , He ₂ , Li ₂ , Be ₂ , B ₂ , C ₂ , N ₂ , O ₂ , F ₂ , Ne ₂ , CO difference between VB and MO theories. Multicentre bonding in electron deficient molecules (B ₂ H ₆). Polarization of covalent molecules, Percentage ionic character from dipole and electronegativity difference. Polarizing power and polarizability; Fajan's rule. Weak interactions, Types of intermolecular forces.	10
2	Salient Features of s- and p-Block Elements: General discussion with respect to all periodic (Occurrence, electronic configuration, atomic & ionic radii, density, ionization potential, metallic behaviour, electropositive nature, electronegativity, electron affinity, hydration energy, flame colouration, photoelectric effect, polarization power, boiling and melting point) and chemical properties (reactivity towards water, oxygen, air and moisture, hydrogen, halogens, ammonia). Diagonal relationship, catenation, inert pair effect, pπ- pπ, dπ-pπ bond, chemistry of hydrides, halides, oxides and oxyacids of p-block elements. Silicates, Boron nitrogen compounds (borazene and boron nitrides), interhalogen compounds, basic properties of iodine.	10
3	Aliphatic Compounds: Chemical reactions of alkanes,	10

	Reactivity-selectivity principle. Mechanism of free radical halogenation of alkanes. Cycloalkanes- Baeyer's strain theory and its limitations, theory of strainless rings. Preparation & Chemical reactions of alkenes- mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with KMnO_4, Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal- ammonia reduction, oxidation and polymerization.	
4	Aromatic Compounds: Aromaticity- the Hückel rule, aromatic ions. Aromatic electrophilic substitution- general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel- Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives.	10
5	Chemical Kinetics and Catalysis: Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction— concentration, temperature, pressure, solvent, light, catalyst; hetero and homocatalysis, significance. Inhibitors, poisons, promoters. Concentration dependence of rates of simple reaction, Molecularity, Order of reaction- zero order, first order, second order, pseudo-order, half-life period. Methods of determination of the order of reaction- differential method, integration method, half-life method and isolation methods, Numerical problems.	10
6	Thermodynamics I: Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, definition of internal energy and enthalpy. Heat capacity – heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Thermochemistry; standard state, standard enthalpy of formation. Hess's law of heat summation and its application. Temperature dependence of enthalpy, Kirchoff's equation (application without derivation) Numerical problems.	10

Books Recommended:

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

- ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
- iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
- viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Wiley, 1994, 1st edition.
- ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
- x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
- xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
- xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
- xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
- xvii. Bariyar, A., Singh, R.P. and Dwivedi, A., "Text Book for B. Sc. Chemistry I", Anu Books, 2019.

Suggested online links:

1. https://www.youtube.com/watch?v=Gg4-go6tTiA&list=PLmxSS9XYst208kJs0npO_v_L-AGkHZJIS
2. https://www.youtube.com/watch?v=sz17_NnMPak&t=51s
3. <https://www.youtube.com/channel/UCUxhnr9H2IYKsuRypG0MAfw/videos>
4. https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
5. <https://www.openlearning.com/courses/introduction-to-physical-chemistry/?cl=1>
6. <https://www.careers360.com/university/indian-institute-of-technology-bombay/chemistry-of-main-group-elements-certification-course>
7. https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
8. <https://nptel.ac.in/courses/104/103/104103071/>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-I, Theory paper-1

Suggested equivalent online courses:

Further Suggestions:

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

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

Course outcomes:

After completing this course, the students will be able to analyse inorganic salt for the presence of acidic and basic radicals, systematically analyse and identify the organic compounds belonging to hydrocarbon category, measure the relative viscosity of a given liquid.

Credits:2	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Inorganic exercise: Salt mixture analysis: Identification of acidic radicals and basic radicals upto I Group in the given salt.	18
3	Organic exercise: Systematic analysis and identification of any two of the following organic compounds (minimum one from each group) i. Simple Hydrocarbons: Naphthalene, Anthracene Biphenyl ii. Hydrocarbons with special elements: <i>m</i> -Dinitrobenzene, <i>p</i> -Dichlorobenzene	18
4	Physical exercise: Determination of relative viscosity of the given liquid using Ostwald viscometer.	18

Suggested Readings:

- i. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- ii. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- iii. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- iv. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- v. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- vi. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
- vii. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
- viii. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Suggestive digital platforms web links

1. <https://www.labster.com/chemistry-virtual-labs/>
2. <https://www.vlab.co.in/broad-area-chemical-sciences>
3. <http://chemcollective.org/vlabs>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have opted Semester-II Theory Paper-I

Suggested equivalent online courses:

Further Suggestions:

One exercise each from salt analysis (one acidic and one basic radical from zero and first group), organic exercise (one hydrocarbon) and physical exercise (relative viscosity) shall be given in the examination.

Distribution of marks shall be as given below:

- | | |
|---|----|
| 1. Inorganic exercise | 25 |
| 2. Organic exercise | 20 |
| 3. Physical | 20 |
| 4. Viva | 10 |
| 5. Home assignment/internal assessment, lab record and attendance | 25 |

Note:

- The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.
- Less than zero mark will not be awarded.
- The total number of students to be examined per batch shall not be more than sixty.
- Duration of the practical examination shall be of **04 (four) hours**.
- Marks obtained in the practical examination have to be submitted to the Head of the department/Principal of the College. The Head of the Department/Principal of the College will make necessary

arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Diploma in Chemical Science					
2	III		General Chemistry-I	Theory	4
			Analytical Procedures-I	Practical	2
2	IV		General Chemistry-II	Theory	4
			Analytical Procedures-II	Practical	2

Semester-III

Paper-I (Theory)

Course Title: General Chemistry-I

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

Course outcomes:

- ✓ This paper provides detailed knowledge of properties of halides, alcohols and phenols, highlighting their chemical reactions and their mechanism.
- ✓ This paper also provides a detailed understanding of the d-block elements and their characteristics.
- ✓ After successful completion of this course, the students will be able to gather the information regarding Werner's theory and VBT of transition metal complexes.
- ✓ Students will be able to learn the basic concepts of spontaneity, chemical and phase equilibrium and able to apply these concepts in predicting the spontaneous reactions and will be able to solve the numerical problems based on these concepts.

Credit: 4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Hours- = 60	

Unit	Contents	Number of Hours
1	Chemistry of Transition Elements (First, second and third Transition Series): Characteristic properties of the elements; electronic configuration, atomic & ionic radii, oxidation states and stability of uncommon oxidation states, ionization energy, boiling	10

	& melting points, complex compound formation, colour, catalytic properties and magnetic properties. coordination number and geometry. Comparative treatment of 3d, 4d and 5d elements, atomic & ionic radii, oxidation state, ionization energy, complex formation tendency, magnetic behaviour.	
2	Coordination Chemistry-I: Definition, terminology (ligand, coordination number, coordination sphere, complex ion etc.), Nomenclature of coordination compounds (IUPAC system), Werner's theory for coordination compounds; its experimental verification, effective atomic number (EAN) concept, 18-electron rule, stability of complexes and factors contributing to the stability, Valence Bond Theory (VBT) for coordination compounds, geometry of complexes (tetrahedral, octahedral, square planar), magnetic properties of complex compounds.	10
3	Alkyl, aryl and vinyl halides.: Preparation and comparison of their chemical properties. Mechanism of nucleophilic substitution reactions, S_N2 and S_N1 reactions with energy profile diagrams.	8
4	Alcohols and Phenols: Alcohols : Preparation and chemical properties Reactions of alcohols. Dihydric alcohols- Chemical reactions of vicinal glycols, oxidative cleavage $[Pb(OAc)_4]$ and HIO_4 and pinacol-pinacolone rearrangement. Trihydric alcohols-methods of formation, chemical reactions of glycerol. Phenols: Preparation and chemical properties acidic character. Comparative acidic strengths of alcohols and phenols, Reactions of phenols. Mechanism of Fries rearrangement, Claisen condensation, Gatterman synthesis, Houben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction, Kolbe reaction.	12
5	Thermodynamics II: Second law of thermodynamics, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical and chemical processes, entropy change for reversible, irreversible and equilibrium condition. Clausius inequality, entropy as criteria of spontaneity and equilibrium. Entropy changes in ideal gases. Gibbs free energy and Helmholtz work functions. Criteria for thermodynamic equilibrium and spontaneity, advantage Gibbs free energy and Helmholtz work functions over entropy change for spontaneity, Gibbs-Helmholtz equation, Numerical problems.	12
6	Chemical Equilibrium: The law of mass action, free energy and equilibrium constant, factors influencing equilibrium constant, relationship between K_p and K_c. Le-Chatelier's principle,	8

	Numerical problems.	
	Phase Equilibrium: Statement and meaning of the terms: phase, component and degree of freedom, Gibbs phase rule, phase equilibria of one component systems- water, carbon dioxide and sulphur. Raoult's and Henry's law.	

Books Recommended:

- i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
- ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
- iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
- viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Wiley, 1994, 1st edition.
- ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
- x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
- xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
- xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
- xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.

Suggested online links:

1. <https://www.youtube.com/watch?v=FmclK9oUkEE&list=PLmxSS9XYst20Pz1SpRl4jdcrv-zh1AoYy>
2. <https://www.youtube.com/watch?v=y67STFWoQ3A&list=PLmUlqVgZsTVV9zQAF-umZzs65MzOU8Ty9>
3. https://www.youtube.com/watch?v=xo2sRayaVyc&list=PLmUlqVgZsTVUAEThwJsJw_WP_E87_yfhCO
4. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
5. <https://nptel.ac.in/courses/104/103/104103071/#>

6. <https://swayam.gov.in/>
7. <https://nptel.ac.in/courses/104/103/104103071/>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Certificate Course in Introductory Chemistry.

Suggested equivalent online courses:

Further Suggestions:

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

Programme/Class: Diploma in Chemical Science	Year: Second	Semester: Third
Paper-II Practical Subject: Chemistry		
Course Code:	Course Title: Analytical Procedures-I	

Course outcomes:

After completing this course, the students will be able to test the inorganic salts for the presence of acidic and basic radicals from IIA and IIB groups. The students will also be able to understand the systematic identification of the organic compounds belonging to alcohols and phenols.

Students will be able to determine the critical solution temperature of partially miscible liquids.

Credits:2	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Inorganic exercise: Inorganic salt analysis including acidic (all) and basic radicals from II A and IIB group.	22
3	Organic exercise: Systematic analysis and identification of organic compounds : Alcohols and Phenols	20

4	Physical exercise: Determination of critical solution temperature (CST)	12
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Suggested Readings:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
- Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
- Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Suggestive digital platforms web links

- <https://www.labster.com/chemistry-virtual-labs/>
- <https://www.vlab.co.in/broad-area-chemical-sciences>
- <http://chemcollective.org/vlabs>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have opted Sem-III Theory Paper-1

Suggested equivalent online courses:

Further Suggestions:

One exercise each from the Inorganic salt (one acidic and one basic radical), organic exercise (one organic compound) and physical exercise (critical solution temperature) shall be given in the examination.

Distribution of marks shall be as given below:

- | | |
|---|----|
| 1. Inorganic exercise | 20 |
| 2. Organic exercise | 25 |
| 3. Physical exercise | 20 |
| 4. Viva | 10 |
| 5. Home assignment/internal assessment, lab record and attendance | 25 |

Note:

- The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.
- Less than zero mark will not be awarded.
- The total number of students to be examined per batch shall not be more than sixty.

- Duration of the practical examination shall be of **04 (four) hours**.
- Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital

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

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

Course outcomes: This paper provides detailed knowledge of synthesis of aldehydes, ketones, carboxylic acids and functional groups inter conversion. The students will be able to describe the concepts of electrochemistry in detail and its applications. Also, they will be able to solve the numerical problems based on these concepts. Students will be able to define the acids and bases on the basis of various concepts/ theories and will be able to identify the position of Inner transition elements in the periodic table and able to explain their properties on the basis of their position.

Credits: 4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Hours- = 60

Unit	Contents	Number of Hours
1	Acids and Bases: Arrhenius concept, Bronsted-Lowry concept, Lux-Flood and Lewis concept of acids and bases; Hard and Soft Acid-Base Theory: Classification of acids and bases as hard and soft. Pearson's hard and soft acid base concept, acid base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.	10
2	Chemistry of Inner Transition Elements: Chemistry of Lanthanides: Electronic configuration, oxidation states, atomic & ionic radii, lanthanide contraction and its consequences, complex formation, colour; Methods of separation of lanthanides- fractional crystallization, fractional precipitation, change in oxidation state, solvent extraction and ion exchange methods. Chemistry of Actinides: General features of actinides-electronic configuration, atomic & ionic radii, ionization potential, oxidation states and complex formation.	10
3	Aldehydes and Ketones: General methods of preparation and their chemical properties. Rosenmund reaction, Stephen's	10

	reduction, Etard reaction, Gattermann Koch reaction, Comparative account of properties of aliphatic and aromatic aldehydes and ketones. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensation. Condensation with ammonia and its derivatives; Wittig reaction, Oxidation of aldehydes, Cannizzaro reaction, Clemmensen reduction.	
4	Carboxylic Acids: General methods of preparation Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Reduction of carboxylic acids, mechanism of decarboxylation. Methods of formation and chemical reactions of hydroxy acids- malic, tartaric. Dicarboxylic acids-methods of preparation and effect of heat and dehydrating agents.	10
5	Electrochemistry I: Electrical transport-conduction in metals and electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Arrhenius theory of electrolytic dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations, Numerical Problems.	8
6	Electrochemistry II: Oxidation state, types of redox reactions, Meaning of electrode (Half-cell), Electrode reactions, standard hydrogen electrode-reference electrode, determination of standard electrode potential, determination of p^H and pK_a from hydrogen standard electrode, sign conventions, electrochemical series and its significance. Galvanic cells, conventional representation of electrochemical cells. EMF of a cell and its measurements, Derivation of Nernst equation for electrode potential of half-cell and for EMF of cell,. Calculation of thermodynamic quantities of cell reactions (ΔG , ΔH and K), Electrolytic and Numerical Problems.	12

Books Recommended:

- i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
- ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
- iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

- viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994, 1st edition.
- ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
- x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
- xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
- xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
- xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.

Suggested online links:

1. <https://www.youtube.com/watch?v=UJgzQ5XP8wQ&list=PLmxSS9XYst20FfphDeS03pqkcuJk0vuvv>
2. <https://www.youtube.com/watch?v=2G79lCT5Os8&list=PLmxSS9XYst23WTFnTWuRg-Ww0k6foth7e>
3. <https://www.youtube.com/watch?v=SNXFYz31iFI&list=PLmUlqVgZsTVUfjMBLDQvNLUbF9CfIrEsef>
4. https://www.youtube.com/watch?v=1t0GDMSzZ9A&list=PLmxSS9XYst21dec_6u2yWWj295Y8pHGrA
5. <https://swayam.gov.in/>
6. <https://www.coursera.org/learn/physical-chemistry>
7. <https://www.mooc-list.com/tags/physical-chemistry>
8. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
9. <https://nptel.ac.in/courses/104/103/104103071/>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have had Passed Sem-III Theory Paper-1

Suggested equivalent online courses:

Further Suggestions:

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

Programme/Class: Diploma in Chemical Science	Year: Second	Semester: Fourth
Paper-II Practical Subject: Chemistry		
Course Code:	Course Title: Analytical Procedures-II	

Course outcomes:

After completing this course, the students will be able to analyze inorganic salts for the presence of acidic radicals including interfering radicals along with basic radicals from III and IV groups, qualitatively differentiate between aldehydes, ketones and carboxylic acids and determine the solubility of salts.

Credits:2	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Inorganic exercise: Inorganic salt analysis including acidic/ Interfering radicals and basic radicals from III and IV groups.	18
3	Organic exercise: Systematic analysis and identification of aldehydes, ketones and carboxylic acids . Differentiation between aldehyde and ketones.	22
4	Physical exercise: Determination of solubility of salts.	14

Suggestive digital platforms web links

1. <https://www.labster.com/chemistry-virtual-labs/>
2. <https://www.vlab.co.in/broad-area-chemical-sciences>
3. <http://chemcollective.org/vlabs>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have Opted Sem-IV Theory Paper-1

Suggested equivalent online courses:

Further Suggestions:

One exercise each from inorganic salt analysis (one acidic and one basic radical), organic exercise (one organic compound) and physical exercise (solubility of salts) shall be given in the examination.

Distribution of marks shall be as given below:

1. Inorganic exercise	20
2. Organic exercise	25
3. Physical exercise	20
4. Viva	10
5. Home assignment/internal assessment, lab record and attendance	25

Note:

- *The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.*
- *Less than zero mark will not be awarded.*
- *The total number of students to be examined per batch shall not be more than sixty.*
- *Duration of the practical examination shall be of **04 (four) hours**.*
- *Marks obtained in the practical examination have to be submitted to the Head of the department/Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital*

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Degree in Bachelor of Science					
3	V		Inorganic Chemistry	Theory	4
			Organic Chemistry	Theory	4
			Analytical Procedures-III	Practical	2
3	VI		Physical Chemistry	Theory	4
			Analytical Chemistry	Theory	4
			Analytical Procedures-IV	Practical	2

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

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

Course Outcomes: Upon successful completion of this course, the students will be able to describe the stability, crystal field theory, electronic spectra and magnetic properties of coordination compounds. They will also learn about organometallic compounds, some industrially important inorganic materials and their applications in various industries. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Metal-Ligand Bonding in Transition Metal Complexes: Limitations of valence bond theory, an elementary idea about crystal field theory (CFT); crystal field splitting of octahedral and tetrahedral complexes, tetragonal distortion (Jahn-Teller distortion, crystal field splitting of square planar and trigonal bipyramidal complexes, factors affecting the crystal-field parameters, calculation of crystal field stabilization energy (CFSE), spectrochemical series. Applications (color and magnetic properties) and limitations CFT. Comparison between VBT	10

	and CFT.	
2	Thermodynamic and Kinetic Aspects of Coordination Compounds: Stability of metal complexes- thermodynamic and kinetic stability, stable and unstable complexes, inert and labile complexes, stepwise and overall stability constants, relationship between the stepwise and overall stability constants, factors affecting the thermodynamic and kinetic stabilities of coordination compounds. Chelate effect and its thermodynamic origin. Determination of binary formation constants by pH-metry and spectrophotometry	10
3	Electronic Spectra of Transition Metal Complexes: Types of electronic transitions, selection rules for d-d transitions, calculations of spectroscopic ground states (Russell Saunders/L-S coupling), Orgel energy level diagram for d^1 , d^4 and d^6 , d^9 tetrahedral and octahedral complexes, discussion of the electronic spectrum of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ complex ion.	8
4	Magnetic Properties of Transition Metal Complexes: Origin of magnetic behavior, concept of magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism and antiferromagnetism, magnetic moments, quenching of orbital magnetic moment by crystal field, magnetic susceptibility-definition relationship with temperature, Curie law and Curie Weiss law. methods of determining magnetic susceptibility; Gouy's and Quincke's methods, magnetic moment, spin only formula, Correlation of μ_s and $\mu_{\text{effective}}$ values, orbital contribution to magnetic moments.	10
5	Organometallic Chemistry: Definition, nomenclature and classification based on nature of metal-carbon bond. EAN and 18-electron rule. Definition, nomenclature, classification, general methods of preparation of organometallic compounds and a brief account of metal-ethylenic complexes. Applications of organometallic compounds-Ziegler-Natta catalyst, Wilkinson catalyst (No mechanism).	8
6	Some Industrially Important Inorganic Materials: Silicones, siloxanes, polymethylhydrosiloxanes, their applications. Phosphazenes, nature of bonding in triphosphazenes. Cement-manufacture, composition and setting. Glass-manufacture, annealing, types and uses. Ceramics-definition, traditional and new ceramics, structure of ceramics. Inorganic fertilizers-essential nutrients for plants, nitrogenous, phosphatic and potash fertilizers.	14

Books Recommended:

- Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
- Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

- iii. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
- iv. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
- v. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
- vi. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

Suggested online links:

1. <https://www.youtube.com/watch?v=0BQ38GEYF7s&list=PLmxSS9XYst22OYcJbKWq66APcEq5pVsL1>
2. <https://www.youtube.com/watch?v=9oQcm281TT0&list=PLmxSS9XYst20MhuKSMREzLhG4ZBIIdNys9>
3. https://www.youtube.com/watch?v=WGd4gOncw9s&list=PLmxSS9XYst22CtJwFrXW_VA9kCp7OP0kn
4. <https://www.youtube.com/watch?v=R4rPlpWT1cA&list=PLmxSS9XYst21uxf3tsohnDUmTRFrvfVv8>
5. <https://www.youtube.com/watch?v=3TWLAJuVN0c&list=PLmxSS9XYst23hk5m9-MsHTpbADe1Mx-p8>
6. <https://www.youtube.com/watch?v=0k4ryWpwhmo&list=PLmxSS9XYst22xP0d02UtcIlgt0GIofvVm>
7. <https://www.youtube.com/watch?v=0ZBMRjyHWfY&list=PLmxSS9XYst205pTMkWPmDa3lv0s6DFoXM>
8. https://www.youtube.com/watch?v=najS_fXL38U&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=6
9. <https://www.youtube.com/watch?v=3VoKRgPj7OI&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=8>
10. <https://www.youtube.com/watch?v=57hQHf1E3PE&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=7>
11. <https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy19/>
12. https://onlinecourses.nptel.ac.in/noc22_cy02/preview
13. <https://nptel.ac.in/courses/104/105/104105033/>
14. <https://nptel.ac.in/courses/104/101/104101079/>
15. https://onlinecourses.nptel.ac.in/noc21_cy12/preview
16. <https://nptel.ac.in/courses/104/108/104108062/>
17. https://onlinecourses.nptel.ac.in/noc21_cy36/preview
18. https://onlinecourses.nptel.ac.in/noc22_cy05/preview
19. <https://nptel.ac.in/courses/104/105/104105033/>
20. <https://www.york.ac.uk/media/chemistry/research/douthwaite/Metal-Ligand%20bonding%20and%20Inorganic%20reaction%20mechanisms.pdf>
21. <https://nptel.ac.in/courses/104/106/104106089/>
22. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566CHE_P3_M5_etext.pdf
23. http://ddugu.ac.in/epathshala_content1.aspx
24. <https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf>
25. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/07.inorganic_chemistry-ii/31.magnetic_properties_of_transition_metal_ions/et/6388_et_che_p7_m31_e-text.pdf

26. <https://egyankosh.ac.in/bitstream/123456789/15794/1/Unit-7.pdf>
27. <https://www.hhrc.ac.in/ePortal/Chemistry/IImsscchem-18pche3-unit1-sv.pdf>
28. <http://www.du.edu.eg/upFilesCenter/sci/1596861612.pdf>
29. <https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf>
30. <https://nptel.ac.in/courses/104/105/104105103/>
31. <https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf>
32. <https://nptel.ac.in/content/storage2/courses/103107086/module1/lecture1/lecture1.pdf>
33. <https://nptel.ac.in/content/storage2/courses/103107086/module4/lecture1/lecture1.pdf>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-III and Sem-IV Theory papers.

Suggested equivalent online courses:

1. <https://www.labster.com/chemistry-virtual-labs/>
2. <https://www.vlab.co.in/broad-area-chemical-sciences>
3. <http://chemcollective.org/vlabs>

Further Suggestions:

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

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

Course Outcomes: Upon successful completion of this course, the students should be able to describe the chemistry of nitrogen containing compounds, the basic understanding of the chemistry of industrially important materials such as lipids, fats, soaps, detergents, dyes and reagents in organic synthesis. Upon completion of this course students may get job opportunities in food, soap, detergent, and other organic material based synthetic labs and industries. Biomolecules such as carbohydrates and proteins are important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can

understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic experimental understanding of carbohydrates and proteins. The course will also help students to learn the synthetic aspects of organometallic compounds and appreciate their industrial aspects.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Lipids and Fats: Lipids & Fats-Definition; classifications; Iodine value, Saponification value, Acid value, Soaps, Detergents and their action mechanism.	12
2	Reagents in Organic Synthesis: Reagent compounds, types of reagents, Bayer's reagent, NBS, n-butyl lithium, chromium trioxide, Fehling reagent, LiAlH ₄ , OsO ₄ , potassium dichromate, potassium permanganate, Raney Ni, sodium borohydride (NaBH ₄), Tollen's reagent.	12
3	Nitrogen Containing Organic Compounds: Nitro compounds: Chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitroarenes and their reduction in acidic, neutral and alkaline medium. Picric acid. Amines: Physical properties, Structural features affecting basicity of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reaction of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.	14
4	Organometallic Compounds: Organomagnesium compounds; the Grignard reagent-formation, structure and chemical reactions. Organozinc compounds; formation and chemical reactions.	10
5	Dyes: Color and constitution, types of dyes, Alizarin, Indigo, Congo red, Malachite green, Methylene blue, Phenolphthalein, Methyl orange.	10
6	Carbohydrates and Proteins: Carbohydrates: Classification, Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Cyclic structure of D (+)-glucose. Mechanism of mutarotation. Proteins: Classification. structure and stereochemistry of amino	12

	acids. Acid-base behavior, Zwitter ions, isoelectric point and electrophoresis, peptides, Levels of structure of protein.	
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Books Recommended:

- Finar, I.L., “Organic Chemistry”, Pearson Education India, 2002, 6th edition.
- Eliel, E.L. and Wilen, S.H., “Stereochemistry of Organic Compounds”, Wiley, 1994, 1st edition.
- Boyd, Morrison and Bhattacharjee, “Organic Chemistry”, Pearson Education India, 2010, 7th edition.
- Mukerji, S.M., “Reaction mechanism in Organic Chemistry”, Laxmi Publications, 2007, 3rd edition.
- Singh, Jagdamba and Yadav, L.D.S., “Undergraduate Organic Chemistry” Pragati Prakashan, India, 2011, Vol 1.
- Loudon, G. Marc, “Organic Chemistry”, Oxford University Press, 2008, 4th edition.
- Madan, R.L., “Chemistry for Degree Students, B. Sc. Third Year”, S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- Bahl, A. and Bahl, B.S. a “Advance Organic Chemistry”, S. Chand Publishing, India, 2010.

Suggested online links:

- https://www.youtube.com/watch?v=xBNv80Dg6nI&list=PLmUlqVgZsTVUk5NkroUmYXvbterBXbk_J
- https://www.youtube.com/watch?v=UgbaIFI_q6E
- <https://www.youtube.com/watch?v=tz0BrCqPTV0&t=15s>
- <https://www.youtube.com/watch?v=2sHILNzTpUU&t=4s>
- <https://www.youtube.com/watch?v=ALaTCbetFSg&t=210s>
- <https://www.youtube.com/watch?v=kruIzuor5v8>
- <https://www.youtube.com/watch?v=IuERNLx-J7k&t=19s>
- <https://www.youtube.com/watch?v=RW7KlYbpNrk&t=1414s>
- <https://www.youtube.com/watch?v=LcUoeFe0iN8>
- <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
- <https://nptel.ac.in/courses/104/103/104103111/>
- <https://nptel.ac.in/courses/104/103/104103071/>
- https://onlinecourses.nptel.ac.in/noc19_cy24/preview
- <https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod10.pdf>

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-III and Sem-IV Theory papers.

Further Suggestions:

Semester-V, Paper-III (Practical)

Course Title: Analytical Procedures-III

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

Course outcomes:

Upon completion of this course, the students will have the knowledge and skills to understand the synthetic methods related to inorganic and organic fields. Also, they can easily analyze the inorganic salts containing acidic radicals and basic radicals from V and VI groups. Students will also be able to and separate the binary organic mixture and identify the organic compounds present in it.

Credits:2	Compulsory
Max. Marks: 25 + 75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Inorganic exercise: i. Inorganic synthesis: Cuprous chloride, potash alum, chrome alum, ferrous oxalate, ferrous ammonium sulphate, tetraamminecopper(II) sulphate and hexaamminenickel(II) chloride. Crystallization of compounds. ii. Inorganic salt analysis: Acidic radicals and basic radicals from V and VI groups.	14
3	Organic exercise: i. Organic qualitative analysis: Separation and identification of organic mixture by water. ii. Organic synthesis: Through nitration, halogenation, acetylation, sulphonation and simple oxidation	40

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have opted Sem-V Theory Paper-1 &2

Suggested equivalent online courses:

1. <https://www.labster.com/chemistry-virtual-labs/>
2. <https://www.vlab.co.in/broad-area-chemical-sciences>
3. <http://chemcollective.org/vlabs>

Further Suggestions:

One exercise each from inorganic synthesis/inorganic salt analysis, organic qualitative analysis and organic synthesis shall be given in the examination.

Distribution of marks shall be as given below:

- | | |
|---|----|
| 1. Inorganic synthesis | 15 |
| 2. Inorganic salt analysis | 15 |
| 3. Organic Qualitative exercise | 25 |
| 4. Organic synthesis | 10 |
| 5. Viva | 10 |
| 6. Home assignment/internal assessment, lab record and attendance | 25 |

Note:

- The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.
- Less than zero mark will not be awarded.
- The total number of students to be examined per batch shall not be more than sixty.
- Duration of the practical examination shall be of **05(five) hours**.
- Marks obtained in the practical examination have to be submitted to the Head of the department/Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital

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

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

Course outcomes: The core concepts of Physical Chemistry have been included in this semester with a view that students' command over these topics will help them to understand the higher chemistry in PG classes. Their understanding of Surface Chemistry, Photochemistry and Solutions will help him to explain the day today phenomenon of the relevant field whereas. Thermodynamics will help them to understand the natural flow of energy. Learning the Quantum Mechanics will help them to praise the beauty of behavior of fundamental particles. The students will also learn the chemistry connection of radioactivity of elements and appreciate their uses in various fields.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Surface Chemistry: Definition of surface phenomenon-Adsorption. Chemical and physical adsorption, Factors affecting adsorption. Isotherm and Isobar. Free energy of adsorption. Quantitative treatment of adsorption, Freundlich's and Langmuir's adsorption model and their applications. Limitation of Langmuir adsorption model. Adsorption in catalysis, characteristics of catalyzed reactions.	10
2	Elementary Quantum Mechanics: Black-body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects. Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle, operator concept, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, Numerical Problems.	12
3	Photochemistry: Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry; Grothuss-Drapper law, Lambert's law, Lambert-Beer's law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, fluorescence,	10

	phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, Numerical Problems.	
4	Solutions and Colligative Properties: Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solutions, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular mass determination. Osmosis, law of osmotic pressure, determination of molecular mass from osmotic pressure. Elevation of boiling point and depression in freezing point, Numerical Problems.	10
5	Thermodynamics III: Statement and concept of residual entropy, third law of thermodynamics, unattainability of absolute zero, Nernst heat theorem. Evaluation of absolute entropy from heat capacity data, Numerical Problems	8
6	Radioactivity: Definition, nature of radioactivity, emission, types of radioactivity, occurrence, Kinetics of radioactivity, rates of radioactive transitions, Applications of radioactivity, Numerical Problems.	10

Books Recommended:

- Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
- Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
- Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
- Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
- Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
- Atkins, P. and de Paula, J. (2005). Physical Chemistry: 7th edition. Oxford University Press.
- Moore, W.J. (1976). Physical Chemistry: 5th edition. Orient Longman Limited.
- Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
- Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
- Introduction to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill

Suggested online links:

- <https://www.youtube.com/watch?v=CMYg3ElZwDY>
- https://www.youtube.com/watch?v=01dY_ILWdMA&t=4s
- https://onlinecourses.nptel.ac.in/noc20_cy27/preview
- https://onlinecourses.nptel.ac.in/noc21_cy20/preview
- <https://www.classcentral.com/course/swayam-chemistry-i-introduction-to-quantum-chemistry-and-molecular-spectroscopy-3981>
- <https://www.classcentral.com/course/swayam-quantum-chemistry-of-atoms-and-molecules-19982>

7. <https://nptel.ac.in/courses/104/108/104108057/>
8. <https://nptel.ac.in/courses/115/101/115101107/>
9. <https://nptel.ac.in/courses/104/101/104101124/>
10. <https://nptel.ac.in/courses/104/105/104105128/>
11. <https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015>
12. https://onlinecourses.nptel.ac.in/noc20_me20/preview
13. <https://www.careers360.com/university/indian-institute-of-technology-kharagpur/concepts-of-thermodynamics-certification-course>
14. <https://www.coursera.org/learn/thermodynamics-intro>
15. https://onlinecourses.nptel.ac.in/noc22_cy14/preview
16. https://onlinecourses.nptel.ac.in/noc20_cy22/preview
17. https://onlinecourses.nptel.ac.in/noc21_cy45/preview
18. https://onlinecourses.nptel.ac.in/noc21_ch48/preview

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-V Theory papers.

Suggested equivalent online courses:

Further Suggestions:

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

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

Course outcomes: After completion of this course, the students will be able to understand the chemistry of biomolecules. They will become acquainted in the field of data analysis. The new frontiers of chemistry such as nano-chemistry and green chemistry are the part of syllabi of this course which boost the knowledge of the students in these fields. The students will also able to understand the analytical techniques such as electro-gravimetric analysis, coulometric analysis, thermogravimetry, polarography and chromatography.

- ✓ Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- ✓ Students will be able to function as a member of an interdisciplinary problem-solving team.
- ✓ Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- ✓ Students will gain an understanding of how to determine the structure of organic molecules using UV, IR and NMR spectroscopic techniques.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks...

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	General Biochemistry: Introduction to biomolecules, Enzymes; Definition, classification. General introduction to hormones. Nucleic acids; Nitrogen bases, purines, pyrimidines, nucleosides, nucleotides, structure of RNA and DNA molecule.	10
2	Data Analysis: Errors; Definition, types of errors, precision, accuracy, absolute, Significant Figures; significant figures in Arithmetics-addition, subtraction, multiplication and division, Mean and Standard deviation, Standard deviation and probability.	10
3	Fundamentals of Nanochemistry: Definition, brief history, classification, general approach of nano synthesis, general methods of characterization, general applications.	08
4	Basics of Green Chemistry: Introduction, role of green chemistry in sustainable development, principles of green chemistry.	07
5	Analytical Techniques: Basic concepts of electro-gravimetric and coulometric analysis. Thermogravimetric analysis. Voltametry; principle of polarography Chromatography: Introduction, types, paper and column chromatography	09
6	Spectroscopy: Ultraviolet (UV) spectroscopy-absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones. Infra-Red (IR) spectroscopy- molecular vibrations, Hooke's Law, selection rules, intensity and position of IR bands, measurement of IR spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds. Nuclear magnetic resonance (NMR) spectroscopy; Proton magnetic resonance (^1H NMR) spectroscopy, nuclear	16

	shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^1H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone, Problems pertaining to the structure elucidation of simple organic compounds using UV, IR and ^1H NMR spectroscopic techniques	
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Books Recommended:

- Clark, J. H., and Macquarrie, D.J., Handbook of Green Chemistry and Technology, Wiley-Blackwell, 2002.
- Anastas, P.T., and Williamson, T.C. Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes, Oxford University Press, New York, 1999.
- Ozin, G.A., Arsenault, A.C. and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, 2008, 2nd edition.
- P. H. Raven, Biology, Tata MacGraw Hill.
- P. Sheeler, Cell and Molecular Biology, John Wiley.
- N. A. Campbell, Biology Pearson.
- L. Styer, Biochemistry, Freeman & Co.
- Outlines of biochemistry. Fourth edition (Conn, Eric E.; Stumpf, P. K.). Wiley India Pvt. Limited

Suggested online links:

- <https://www.youtube.com/watch?v=qJMJUtgVUVw>
- <https://www.youtube.com/watch?v=58pAYgrZjF0&t=26s>
- https://onlinecourses.nptel.ac.in/noc19_mm21/preview
- <https://www.classcentral.com/course/swayam-introduction-to-data-analytics-3973>
- https://onlinecourses.nptel.ac.in/noc21_cy26/preview
- <https://www.classcentral.com/course/swayam-biochemistry-5229>
- https://onlinecourses.nptel.ac.in/noc19_cy18/preview

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-V Theory papers.

Suggested equivalent online courses:

Further Suggestions:

Semester-VI, Paper-III (Practical)

Course Title: Analytical Procedures-IV

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

Course outcomes: Upon completion of this course, the students will have the knowledge and skills to determine the heat of neutralization, solubility of organic compounds by titration method. They will be able to estimate different metal ions through gravimetric exercise. Chromatographic exercise will train them to take the chromatograms of organic compounds. Students will also be able to separate the binary organic mixture using NaHCO_3 separation and identify the organic compounds present in it.

Credits: 2	Compulsory
Max. Marks: 25+75	Min. Passing Marks:.....

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	Physical exercise: i. Determination of solubility of organic compound (viz. oxalic acid) in water by titration method. ii. Determination of Heat of neutralization.	18
3	Organic exercise: Separation & identification of binary mixture of organic compounds using NaHCO_3 (Sodium bicarbonate).	18
4	Inorganic Exercise: Gravimetric analysis of any one or two metal ions; Ba^{2+} , Fe^{3+} , Ni^{2+} , Cu^{2+} , Zn^{2+} etc.	10
5	Chromatographic technique: Demonstrative Chromatography- paper chromatography (separation of organic compounds- Amino acids/ dyes)	8

Suggested Continuous Evaluation Methods for Internal Assessment: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	12 marks
Record and overall performance	13 marks

Course prerequisites: To study this course, a student must have opted Sem-VI Theory Paper-1 &2

Further Suggestions:

One exercise each from inorganic analysis (quantitative), Organic mixture and physical exercise shall be given in the examination.

Distribution of marks shall be as given below:

1. Inorganic exercise	20
2. Organic exercise	25
3. Physical exercise	20
4. Viva	10
5. Home assignment/internal assessment, lab record and attendance	25

Note:

- *The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.*
- *Less than zero mark will not be awarded.*
- *The total number of students to be examined per batch shall not be more than sixty.*
- *Duration of the practical examination shall be of 05(five) hours.*
- *Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital*

