Academic Council Meeting No. and Date : 8 / September 04, 2023

Agenda Number : 2 Resolution Number : 34, 35 / 2.2, 2.23

Vidya Prasarak Mandal's B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme: Bachelor of Science

Specific Programme: Chemistry

Level 4.5

CHOICE BASED GRADING SYSTEM

[F.Y.B.Sc. (Chemistry)]

Initiated in Academic year 1969-1970	Revised under NEP Academic year 2023 - 2024

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Preamble

The B.Sc. (Chemistry) programme is aimed to make the students employable and impart industry oriented training. The main objectives of the course are:

- To develop an aptitude to engage in continuing professional development.
- To work effectively as a part of a team to achieve a common stated goal.
- To be capable of managing complex chemical projects with consideration of the human, financial and environmental factors.
- To think analytically, creatively and critically in developing robust, extensible and highly maintainable technological solutions to simple and complex problems.
- To apply their knowledge and skills to be employed and excel in chemical industrial work.
- To communicate effectively with a range of audiences both technical and non-technical.

The syllabus is aimed to achieve the objectives. The syllabus spanning three years covers the industry relevant courses. The students will be ready for the jobs available in different fields like:

- History of Indian chemical science
- Introduction to physical concepts use for the chemical systems
- Study of thermodynamics, chemical kinetics, molecular spectroscopy, solid state, etc.
- Detailed study of periodic table
- Introduction to aliphatic and aromatic compounds
- Study of stereochemistry
- Introduction to analytical chemistry
- Study of safety precaution use in chemical laboratory
- Be skillful in handling various glassware and instruments

BOS Chairperson: Prof. Dr. Anita.S.Goswami-Giri

Eligibility:
Passed 12th standard (HSC) of Maharashtra State Board / CBSE / ICSE board with Mathematics as one of the subject.
Duration : 3 years (level 4.5)
Mode of Conduct:
Laboratory practicals / Offline lectures / Online lectures
Eligibility For certificate if exit at level 4.5
Program Outcome

Student graduating with the Degree BSc Chemistry should be able to:

- Understand fundamental concepts in Physical, Inorganic, Organic, Analytical Chemistry and also all other allied subject areas.
- Students should be able to characterize, identify and separate components of organic, inorganic and also able to analyze them by making use of instrumental methods learned.
- Develop critical thinking ability by way of solving problems using basic chemistry knowledge.

Program Specific Outcome

- Study of structure, properties, reaction and application of chemical systems.
- Study of safety precaution use in chemical laboratory.
- Select and apply current techniques, skills, and tools necessary in chemical laboratory.
- Study of basics of Physical chemistry, Inorganic chemistry, Organic chemistry and Analytical chemistry.

Pedagogy:

- $ Assignment Desk work, internal tests, Assignments, Quiz, ppt presentation You tube videos, referencing , MOOC, Problem solving, Project work, Industrial Visit, internship etc Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project based learning/ case studies/self-study like seminar, term paper or MOOC
- $ Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning)

➢ Assessment: Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40 %	60 %
Practical	-	100 %
Experimental learning	-	100 %
Visits	-	100 %

BOS Chairperson: Prof. Dr. Anita.S.Goswami-Giri

VPM's B.N.Bandodkar College of Science (Autonomous), Thane
F.Y.B.Sc. (Chemistry)
Structure of Programme

Semester 1: Major			
Course Code	**Course Title**	**No. of lectures In hrs**	**Credits**
23BUCH1T1	Chemistry Major 1	**30**	**2**
23BUCH1T2	Chemistry Major 2	**30**	**2**
23BUCH1P1	Chemistry Practicals	**60**	**2**
23BU1SEC7	SEC- **Preparation of Standard Solutions and reagents**	**45**	**2**
	Total	**165**	**8**
Semester 1: Minor			
Course Code	**Course Title**	**No. of lectures In hrs**	**Credits**
23BUCH1T3	Chemistry Minor 1	**30**	**2**
23BUCH1T4	Chemistry Minor 2	**30**	**2**
23BUCH1P2	Chemistry Practicals	**60**	**2**
	Total	**120**	**6**
Semester 1: Generic			
23BUCH1T5	Chemistry -I (Generic-1) **Indian Pioneers in Chemical Sciences and Chemistry in Everyday Life**	**30**	**2**
	Total	**30**	**2**
Semester 1 **Optional Electives -Interdisciplinary Sciences**			
23BUID1T6	**Soft skills and personality development-I**	**30**	**2**
	Total	**30**	**2**
Semester 1 - (AEC)			
23BUEN1T8	**Basic English Learning course**	**30**	**2**
	Total	**30**	**2**
Semester 1 - Indian Knowledge System			
23BUIK1T9	The Ancient Indian Social Structure. -I	**30**	**2**
	Total	**30**	**2**

Semester 2: Major			
Course Code	**Course Title**	**No. of lectures In hrs**	**Credits**
23BUCH2T1	Chemistry Major 1	**30**	**2**
23BUCH2T2	Chemistry Major 2	**30**	**2**
23BUCH2P1	Chemistry Practicals	**60**	**2**
23BU2SEC7	SEC - **Introduction to Instrumental techniques**	**45**	**2**
Total		**165**	**8**
Semester 2: Minor			
Course Code	**Course Title**	**No. of lectures In hrs**	**Credits**
23BUCH2T3	Chemistry Minor 1	**30**	**2**
23BUCH2T4	Chemistry Minor 2	**30**	**2**
23BUCH2P2	Chemistry Practicals	**60**	**2**
Total		**120**	**6**
Semester 2: Generic			
23BUCH2T5	Chemistry -I (Generic-2) **Safety in Chemical Laboratory and cosmetics**	**30**	**2**
Total		**30**	**2**
Semester 2 **Optional electives Interdisciplinary sciences**			
23BUID2T6	**Soft skills and personality development-II**	**30**	**2**
	Total	**30**	**2**
Semester 2 (AEC)			
23BUEN2T8	**Scientific *English Writing***	**30**	**2**
	Total	**30**	**2**
Semester 2- Indian Knowledge System			
23BUIK2T9	The Ancient Indian Social Structure. -II	**30**	**2**
Total		**30**	**2**

Note: AEC, IKS, Open elective syllabus view separately.

SEMESTER-I

Major

Semester I: Major

Course Code 23BUCH1T1	Course Title Major 1	Credits 2	No. of lectures in hrs.
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Provides general knowledge for the determination of the sequence of elementary reactions and its mechanism. • Study of properties and applications of liquid state • Classification of elements in periodic table. • Basics of Organic Chemistry. • Study of basics of atomic structure.			
Unit I :	**1.1 Chemical Kinetics: (5L)** Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, integrated rate equation of first and second order reactions (with equal initial concentration of reactants) (Numericals expected) Determination of order of reaction by (a) Integration method (b) Graphical method (c) Ostwald's isolation method (d) Half time method (Numericals expected) **1.2 Liquid State: (5L)** **Surface tension:** Introduction, methods of determination of surface tension by drop number method (Numericals expected) **Viscosity:** Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer (Numericals expected) **Refractive index:** Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer (Numericals expected) **Liquid crystals:** Introduction, classification and structure of thermotropic phases (Nematic, smectic and cholesteric phases), applications of liquid crystals **1.3. Periodic Table and periodicity : (5L)** Long form of Periodic Table; Classification for elements as main group, transition and inner transition elements; **Periodicity in the following properties :** Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater's rule); electronegativity ; Pauling, Mulliken and Alred Rochow electronegativities (Numerical problems expected, wherever applicable.)		**15**
Unit II :	**2.1) Hydrogenic atoms (5L)** **1.** Simple principles of quantum mechanics;		**15**

	2. i) Atomic orbitals ii) Shells, subshells and orbitals **3.** Many Electron Atoms **i)** Penetration and shielding **ii)** Effective nuclear charge **4.** Aufbau principle **2.2) Basics of Organic Chemistry (10L)** **2.2.1.** Classification and Nomenclature of Organic Compounds: Review of basic rules of IUPAC nomenclature. Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds: alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues. **2.2.2** Bonding and Structure of organic compounds: Hybridization: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide)		
Course Code **23BUCH1T2**	**Course Title** **Major 2**	**Credits** **2**	**No. of lectures in hrs.**
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Understand the various physical laws and rules which applied for chemical system • Study of properties and applications of thermodynamics etc. • Study inorganic compounds • Basics of stereochemistry			
Unit I :	**1.1 Chemical Thermodynamics 1** Thermodynamic terms: System, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state functions and path functions, zeroth law of thermodynamics First law of thermodynamics: concept of heat (q), work (w), internal energy (U), statement of first law, enthalpy, relation between heat capacities, sign conventions, calculations of heat (q), work (w), internal energy (U), and enthalpy (H) (Numericals expected) **1.2 Thermochemistry**: Heats of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculation of bond energy, bond		**15**

	dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (Numericals expected). **1.3 Comparative chemistry of Main Group Elements** Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behaviour of second period elements, allotropy, catenation, diagonal relationship.	
Unit II :	**2.1 Comparative chemistry of Main Group Elements** Comparative chemistry of carbides, nitrides, oxides and hydroxides of group I and group II elements. Some important compounds- $NaHCO_3$, Na_2CO_3. **2.2 Stereochemistry I:** Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 dichlorobutane) and their interconversions; Geometrical isomerism in alkene and cycloalkanes: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). Relative and absolute configuration: D/L and R/S designations.	**15**

SEMESTER-I

Minor

Semester I: Minor

<table>
<tr><th>Course Code
23BUCH1T3</th><th>Course Title
Minor 1</th><th>Credits
2</th><th>No. of lectures in hrs.</th></tr>
<tr><td colspan="4">Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to
Provides general knowledge for the determination of the sequence of elementary reactions and its mechanism.
Study of properties and applications of liquid state
Classification of elements in periodic table.
Basics of Organic Chemistry.
Study of basics of atomic structure.</td></tr>
<tr><td>Unit I :</td><td colspan="2">1.1 Chemical Kinetics: (5L)
Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, integrated rate equation of first and second order reactions (with equal initial concentration of reactants) (Numericals expected)
Determination of order of reaction by (a) Integration method (b) Graphical method (c) Ostwald’s isolation method (d) Half time method (Numericals expected)

1.2 Liquid State: (5L)
Surface tension: Introduction, methods of determination of surface tension by drop number method (Numericals expected)
Viscosity: Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer (Numericals expected)
Refractive index: Introduction, molar refraction and polarizability, determination of refractive index by Abbe’s refractometer (Numericals expected)
Liquid crystals: Introduction, classification and structure of thermotropic phases (Nematic, smectic and cholesteric phases), applications of liquid crystals
1.3. Periodic Table and periodicity : (5L)
Long form of Periodic Table; Classification for elements as main group, transition and inner transition elements; Periodicity in the following properties : Atomic and ionic</td><td>15</td></tr>
</table>

	size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater's rule); electronegativity ; Pauling, Mulliken and Alred Rochow electronegativities (Numerical problems expected, wherever applicable.)	
Unit II :	**2.1) Hydrogenic atoms (5L)** **1.** Simple principles of quantum mechanics; **2.** i) Atomic orbitals ii) Shells, subshells and orbitals **3.** Many Electron Atoms **i)** Penetration and shielding **ii)** Effective nuclear charge **4.** Aufbau principle **2.2) Basics of Organic Chemistry (10L)** **2.2.1.** Classification and Nomenclature of Organic Compounds: Review of basic rules of IUPAC nomenclature. Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds: alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues. **2.2.2** Bonding and Structure of organic compounds: Hybridization: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide)	**15**

Course Code **23BUCH1T4**	**Course Title** **Minor 2**	**Credits** **2**	**No. of lectures in hrs.**

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Understand the various physical laws and rules which applied for chemical system
- Study of properties and applications of thermodynamics etc.
- Study inorganic compounds
- Basics of stereochemistry

Unit I :	**1.1 Chemical Thermodynamics 1** Thermodynamic terms: System, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state functions and path functions, zeroth law of thermodynamics First law of thermodynamics: concept of heat (q), work (w), internal energy (U), statement of first law, enthalpy, relation between heat capacities, sign conventions, calculations of	**15**

	heat (q), work (w), internal energy (U), and enthalpy (H) (Numericals expected) **1.2 Thermochemistry**: Heats of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (Numericals expected). **1.3 Comparative chemistry of Main Group Elements** Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behaviour of second period elements, allotropy, catenation, diagonal relationship.	
Unit II :	**2.1 Comparative chemistry of Main Group Elements** Comparative chemistry of carbides, nitrides, oxides and hydroxides of group I and group II elements. Some important compounds- $NaHCO_3$, N_a2CO_3. **2.2 Stereochemistry I:** Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 dichlorobutane) and their interconversions; Geometrical isomerism in alkene and cycloalkanes: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). Relative and absolute configuration: D/L and R/S designations.	**15**

References

Semester 1					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Physical Chemistry	I. N. Levine	Tata Mc Graw Hill	**6th**	**2010**
2.	Molecular Thermodynamics	D. A. McQuarrie	Viva Books Pvt. Ltd.,New Delhi		2004
3.	Physical Chemistry	P.W. Atkins	Oxford University Press	10th	2014
4.	Concise Inorganic	J. D. Lee	ELBS		1991

	Chemistry				
5.	Stereochemistry Conformation and Mechanism	Kalsi, P. S.	New Age International	-	2005
6.	Organic Chemistry	R. T. Morrison	Dorling Kindersley (India) Pvt Ltd. (Pearson Education)	-	2011
7.	Stereochemistry of Organic Compounds Principles and Applications	D. Nasipuri	New Age International Publishers	**2nd**	2012

Semester I

Course Code 23BUCH 1T5	**Course Title Generic Indian Pioneers in Chemical sciences and Chemistry in Everyday Life**	**Credits 2**	**No. of lectures in hrs.**
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • History of Indian chemical science • Chemistry in Everyday Life (Food chemistry)			
Unit I :	**HISTORY OF SCIENCE:** General history of Chemical science **Indian Pioneers in Chemical sciences :** 1. **Prof. C. N. R. Rao:** Area of research: Prof. C. N. R. Rao is a leading Indian scientist in the field of solid state and materials chemistry. His major area of research comprises transition metal oxides and other extended inorganic solids, inorganic-organic hybrid materials, nanomaterials and the generation of hydrogen by photocatalysis. 2. **Acharya P. C. Ray:** Area of research: Acharya P. C. Ray established the first modern research in Chemistry and is regarded as the father of chemical science in India. He published around 150 research articles during his lifetime. He discovered the stable compound mercurous nitrite in 1896 and established Bengal chemical and Pharmaceutical Works Ltd, India's first pharmaceutical company in 1901. 3. **Prof. H. J. Arniker:** Area of research: Prof. H. J. Arniker was worked in the field of Radiochemistry and Allied sciences. He was applied Neutron activation analysis in the various fields of chemical science. 4. **Har Govind Khurana:** Area of research: The researcher shared the 1968 Nobel prize for Physiology or Medicine with Marshall W. Nirnberg and Robert W. Holley for research that showed how the order of nucleotides in nucleic acids, which		**15**

	carry genetic code of the cell, control the cell's synthesis of proteins. 5. **Dr. Yusuf Khwaja Hamid:** Area of research: Dr. Yusuf Khwaja Hamid is a Polish born Indian scientist, the chairman of Cipla, a generic pharmaceuticals company founded by his father Kwaja Abdul Hamied in 1935. He is also an elected fellow of the Indian National Science Academy. 6. **Dr. Asima Chatterjee:** Area of research: Dr. Asima Chatterjee was an Indian organic chemist noted for her work in the fields of organic chemistry and phytomedicine. Her most notable work includes research on vinca alkaloids, the development of anti-epileptic drugs and the development of anti-malarial drugs. 7. **Prof. S. R. Gadre:** Area of research: Prof. S. R. Gadre is an Indian scientist working in computational quantum and theoretical chemistry. He has authored authors over 200 publications mostly in highly impact factors.	
Unit II :	**Chemistry in Everyday Life** **Introduction to food chemistry** **1.** Food processing and preservation: Introduction, need, chemical methods, action of chemicals (Sulphur dioxide, boric acid, sodium benzoate, acetic acid, sodium chloride and sugar) and pH control **2.** Physical methods (Pasteurization: LTLT, HSST and Irradiation**)** **3.** Detection of adulterants in Milk: Sugar, Starch, H_2O_2, Formalin, Urea, Ammonium sulphate, Detergent, Borax	**15**

References

Semester 1					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Analysis of food and Beverages	George Charalanbous	Academic press	1st	1978
2.	An Advance Dairy chemistry	P. F. Fox, P. L. H. McSweeney	Springer	Volume 3	1997
3.	Food Analysis: Theory and practice	Yeshajahu Pomeranz, Clifton E. Meloan	Springer	3rd	1978
4.	Food Analysis	Edited by S. Suzanne Nielsen	Springer	**5th**	2017
5.	Government of India publications of food drug cosmetic act	-	-	-	-

	and rules.				

Semester I

Course Code 23BU1SEC7	Course Title SEC- Preparation of Standard Solutions and reagents	Credits 2	No. of lectures in hrs.

Course outcome:

- To brand students independent in constructing curves/plots using which evaluation of exact amount or strength of selected component present in unknown sample.
- To impart skills which they require while seeking jobs and to sharpen their knowledge and need to understand concepts and issues at their workplace

UNIT NO	COURSE CONTENTS	NO. OF LECTURES in hrs.	NO. OF PRACTICALS in hrs.
I	**Introduction** Accuracy, precision, calibration of glass wares and its importance	3	6
II	**Chemical Calculations** Normality, Molarity, Molality, Formality, ppm, ppb, Millimoles, Milliequivalents, Mole fraction, Weight ratio, Volume ratio and weight to volume ratio.	3	6
III	**Standard solutions** Concept of Primary standard solution and Secondary standard solution.	3	6
IV	**Titrimetric analysis** Types of reactions and construction of titration curves.	3	6
V	**Indicators** Theoryof indicators, Preparation of indicators, Types of indicators, Mechanism of indicator action	3	6
	Total Period = 45	15	30
	Credit = 02		

Practicals: Major

Course Code 23BUCH1P1	Course Title Chemistry Practical	Credits 2	No. of lectures in hrs.

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Be skillful in handling various glassware and instruments.
- Actively participate in chemical laboratories.
- Study of commercial analysis of various organic and inorganic compounds.
- Learned basics of chemical analysis.

1. To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations

2. To determine the rate constant for the hydrolysis of ester using HCl as catalyst-I (Experiment)

3. To determine the rate constant for the hydrolysis of ester using HCl as catalyst- II (Calculation, graph and results)

4. To determine enthalpy of dissolution of salt (like KNO_3)

Commercial analysis of----

5. Mineral acid

6. Organic acid

7. Salt of weak acid and strong base.

8. Titration using double indicator: analysis of solution of Na_2CO_3 and $NaHCO_3$.

Gravimetric analysis

9. To determine the percent purity of sample of $BaSO_4$ containing NH_4Cl

10. To determine the percent purity of ZnO containing $ZnCO_3$.

60

Purification of any four organic compounds by recrystallization selecting suitable solvent. (Provide 1g.).

Learners are expected to report

a) Solvent for recrystallization.

b) Mass and the melting points of purified compound.

11. Sample-1

12. Sample-2

13. Sample-3

14. Sample-4

(Learners should calibrate thermometer before determining melting point.)

15. Chromatography

Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC)

Practicals: Minor

Course Code 23BUCH1P2	Course Title Chemistry Practical	Credits 2	No. of lectures in hrs.
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Be skillful in handling various glassware and instruments. • Actively participate in chemical laboratories. • Study of commercial analysis of various organic and inorganic compounds. • Learned basics of chemical analysis.			
1. To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations **2.** To determine the rate constant for the hydrolysis of ester using HCl as catalyst-I (Experiment) **3.** To determine the rate constant for the hydrolysis of ester using HCl as catalyst- II (Calculation, graph and results) **4.** To determine enthalpy of dissolution of salt (like KNO_3)			**60**
Commercial analysis of- **5.** Mineral acid **6.** Organic acid **7.** Salt of weak acid and strong base. **8.** Titration using double indicator: analysis of solution of Na_2CO_3 and $NaHCO_3$. **Gravimetric analysis-** **9.** To determine the percent purity of sample of $BaSO_4$ containing NH_4Cl **10.** To determine the percent purity of ZnO containing $ZnCO_3$.			
Purification of any four organic compounds by recrystallization selecting suitable solvent. (Provide 1g.). Learners are expected to report a) Solvent for recrystallization. b) Mass and the melting points of purified compound. **11.** Sample-1 **12.** Sample-2 **13.** Sample-3 **14.** Sample-4 (Learners should calibrate thermometer before determining melting point.) **15.** Chromatography Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC)			

References for practical

Semester 1					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Senior Practical Physical Chemistry	B. D. Khosla	-	-	2011
2.	Vogel's *Quantitative Chemical Analysis*	J. Mendham	**Pearson**	**6th**	2009
3.	Practical Organic Chemistry	F.G. Mann,	Pearson Education	-	2009
4.	Textbook of Practical Organic Chemistry	A. I. Vogel	Prentice-Hall	**5th**	1996

SEMESTER-II

Major

Semester 2: Major

<table>
<tr><th>Course Code
23BUCH2T1</th><th>Course Title
Major 1</th><th>Credits
2</th><th>No. of lectures in hrs.</th></tr>
<tr><td colspan="4">Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to
• Study of thermodynamic parameters of chemical system.
• Study of acid-base theory.
• Introduction of analytical chemistry.
• Learned chemistry of aliphatic compounds.</td></tr>
<tr><td>Unit I :</td><td colspan="2">1.1 Gaseous State: (10L)
Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann’s distribution of velocities (qualitative discussion), ideal gases, real gases, compressibility factor, Boyle’s temperature (Numericals expected)
Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals equation of state, Joule-Thomson effect: qualitative discussion and experimentation, inversion temperature. (Numericals expected)
Statement of second law of thermodynamics, concepts of entropy and free energy, spontaneity and physical significance of free energy.
1.2 Acid Base Theories: (5L)
Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Hard and Soft acids and bases.</td><td>15</td></tr>
<tr><td rowspan="2">Unit II :</td><td colspan="2">2.1 Concept of Qualitative Analysis: (5L)
Precipitation equilibria, effect of common ions, uncommon ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations and numerical problems expected.)</td><td rowspan="2">15</td></tr>
<tr><td colspan="2">2 Chemistry of Aliphatic Hydrocarbons
2.1 Carbon-Carbon pi bonds: (10L)
2.1.1 Formation of alkenes and alkynes by elimination reactions: Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.
2.1.2 Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction(catalytic and chemical), syn and anti-</td></tr>
</table>

	hydroxylation (oxidation). 1, 2-and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination using N-bromosuccinimide and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.		
Course Code 23BUCH 2 T2	**Course Title Major 2**	**Credits 2**	**No. of lectures in hrs.**
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Study of ionic equilibria, molecular thermodynamics, etc. • Introduction of redox reaction • Detail study of stereochemistry. • Brief overview of aromatic compounds.			
Unit I :	**1.1 Ionic Equilibria (5L)** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono-, di- and triprotic acid (exact treatment for monoprotic acid) Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected) **1.2 Molecular Spectroscopy: (5L)** Electromagnetic radiation, electromagnetic spectrum, Planck's equation, interaction of electromagnetic radiation with matter: Absorption, emission, scattering, flourescence, electronic, vibrational and rotational transitions, Beer-Lambert's law (Numericals expected) **1.3 Chemical Bond and Reactivity: (5L)** Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for AB_n type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.		**15**
Unit II :	**2.1 Oxidation Reduction Chemistry: (5L)** **a)** Reduction potentials		**15**

	b) Redox potentials: half reactions; balancing redox equations. **c)** Redox stability in water **i)** Latimer and Frost Diagrams **ii)** pH dependence of redox potentials. **d)** Applications of redox chemistry Redox reagents in Volumetric analysis: a) I_2; b) $KMnO_4$ **2.2 Stereochemistry-II: Cycloalkanes and Conformational Analysis: (5L)** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy. **2.3 Aromatic Hydrocarbons: (5L)** Aromaticity: Hückel's ruleanti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation with their mechanism. Hammond's postulate, Directing effects of the groups.	

SEMESTER-II

Minor

Semester 2: Minor

<table>
<tr><th>Course Code
23BUCH2T3</th><th>Course Title
Minor 1</th><th>Credits
2</th><th>No. of lectures in hrs.</th></tr>
<tr><td colspan="4">Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to
• Study of thermodynamic parameters of chemical system.
• Study of acid-base theory.
• Introduction of analytical chemistry.
• Learned chemistry of aliphatic compounds.</td></tr>
<tr><td>Unit I :</td><td colspan="2">1.1 Gaseous State: (10L)
Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann’s distribution of velocities (qualitative discussion), ideal gases, real gases, compressibility factor, Boyle’s temperature (Numericals expected)
Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals equation of state, Joule-Thomson effect: qualitative discussion and experimentation, inversion temperature. (Numericals expected)
Statement of second law of thermodynamics, concepts of entropy and free energy, spontaneity and physical significance of free energy.
1.2 Acid Base Theories: (5L)
Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Hard and Soft acids and bases.</td><td>15</td></tr>
<tr><td rowspan="2">Unit II :</td><td colspan="2">2.1 Concept of Qualitative Analysis: (5L)
Precipitation equilibria, effect of common ions, uncommon ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations and numerical problems expected.)</td><td rowspan="2">15</td></tr>
<tr><td colspan="2">3 Chemistry of Aliphatic Hydrocarbons
3.1 Carbon-Carbon pi bonds: (10L)
2.1.1 Formation of alkenes and alkynes by elimination reactions: Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.
2.1.2 Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction(catalytic and chemical), syn and anti-</td></tr>
</table>

	hydroxylation (oxidation). 1, 2-and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination using N-bromosuccinimide and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.		
Course Code 23BUCH 2 T4	**Course Title Minor 2**	**Credits 2**	**No. of lectures in hrs.**
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Study of ionic equilibria, molecular thermodynamics, etc. • Introduction of redox reaction • Detail study of stereochemistry. • Brief overview of aromatic compounds.			
Unit I :	**1.1 Ionic Equilibria (5L)** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono-, di- and triprotic acid (exact treatment for monoprotic acid) Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected) **1.2 Molecular Spectroscopy: (5L)** Electromagnetic radiation, electromagnetic spectrum, Planck's equation, interaction of electromagnetic radiation with matter: Absorption, emission, scattering, flourescence, electronic, vibrational and rotational transitions, Beer-Lambert's law (Numericals expected) **1.4 Chemical Bond and Reactivity: (5L)** Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for AB_n type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.		**15**
Unit II :	**2.3 Oxidation Reduction Chemistry: (5L)** **a)** Reduction potentials **b)** Redox potentials: half reactions; balancing redox equations.		**15**

	c) Redox stability in water **i)** Latimer and Frost Diagrams **ii)** pH dependence of redox potentials. **d)** Applications of redox chemistry : Redox reagents in Volumetric analysis: a) I2; b) $KMnO_4$ **2.4 Stereochemistry-II: Cycloalkanes and Conformational Analysis: (5L)** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy. **2.3 Aromatic Hydrocarbons: (5L)** Aromaticity: Hückel's ruleanti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation with their mechanism. Hammond's postulate, Directing effects of the groups.	

References

Semester 2					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Physical Chemistry	I. N. Levine	Tata Mc Graw Hill	**6th**	**2010**
2.	Molecular Thermodynamics	D. A. McQuarrie	Viva Books Pvt. Ltd.,New Delhi		2004
3.	Physical Chemistry	P.W. Atkins	Oxford University Press	10th	2014
4.	Concise Inorganic Chemistry	J. D. Lee	ELBS		1991
5.	Stereochemistry Conformation and Mechanism	Kalsi, P. S.	New Age International	-	2005
6.	Organic Chemistry	R. T. Morrison	Dorling Kindersley (India) Pvt Ltd. (Pearson Education)	-	2011
7.	Stereochemistry of Organic Compounds Principles and applications	D. Nasipuri	New Age International Publishers	**2nd**	2012

Semester II

Course Code 23BU2SEC7	Course Title SEC – Introduction to Instrumental techniques	Credits 2	No. of lectures in hrs.

UNITNO	COURSE CONTENTS	NO. OF LECTURES in hrs.	NO. OF PRACTICALS in hrs.
I.	**Instrumental techniques**		
II.	**i. pH-meter** Principle, instrumentation and application	**2**	**4**
III.	**ii. Conductometer** Principle, instrumentation and application	**2**	**4**
IV.	**Iii Potentiometer** Principle, instrumentation and application	**2**	**6**
V.	**iv. Spectrophotometer** Principle, instrumentation and application	**4**	**8**
VI.	**v. Flame Emission spectrophotometer** Principle, instrumentation and application	**5**	**8**
VII.	**Total Period = 45**	**15**	**30**
	Credit = 02		

Semester II

Course Code 23BUCH2T5	Course Title Generic Safety in Chemical Laboratory and cosmetics	Credits 2	No. of lectures in hrs.
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to • Understand the Safety in Chemical Laboratory • Study of Cosmetics and estimation of main constituents			
Unit I :	**1. Safety in Chemical Laboratory** Basic concepts of Safety in Laboratories, Personal Protection Equipment (PPE), OSHA, Toxic Hazard (TH) classifications, Hazardous Chemical Processes (including process calorimetry / thermal build up concepts). **2. Quality Management System (QMS):** Evolution and significance of Quality Management, types of quality standards for laboratories, total quality management (TQM), philosophy implementation of TQM (reference of Kaizen, Six Sigma approach & 5S), quality audits and quality reviews, responsibility of laboratory staff for quality and problems**.** **3. Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) **4. Good Laboratory Practices (GLP)** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score		**15**
Unit II :	**1. Cosmetics:** Introduction and sensory properties **2. Study of cosmetic products:** **2.1.**Face powder: Composition, Estimation of calcium and magnesium by complexometric titration **2.2.**Lipstick: Constituents, Ash analysis for water soluble salts: borates, carbonates and zinc oxide **2.3.**Deodorants and Antiperspirants: Constituents, properties Estimation of zinc by gravimetry		**15**

References:

Semester 2					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Safety and Hazards Management in Chemical Industries	M N Vyas	Atlantic Publisher	Ch:4, Ch:5 & Ch:19	2020
2.	Industrial Hygiene and Chemical Safety	M H Fulekar	IK International Pvt. Ltd.	Ch:9, Ch:11 & Ch:15	2006
3.	Quality Management	Donna C S Summers	Pearson	2nd, Ch:3	2008
4.	Quality in the Analytical Laboratory	Elizabeth Pichard	Wiley India	Ch: 5, Ch: 6 & Ch: 7	1995
5.	ISO 9000 Quality Systems Handbook	David Hoyle	Butterworth-Heinemann publications	Fourth Edition, Chapter: 3 & 4	2001
6.	Quality in Totality: A Manager‟s Guide To TQM and ISO 9000	Parag Diwan	Deep & Deep Publications	1st Edition	2000
7	OECD Principles of Good Laboratory Practice (as revised in 1997)"	-	OECD Environmental Health and Safety Publications, OECD.	**1st**	1998
8	A systematic approach for evaluating the quality of experimental toxicological and eco-toxicological data".	Klimisch, HJ; Andreae, M; Tillmann, U	REGULATORY TOXICOLOGY AND PHARMACOLOGY 25, 1–5 (1997) ARTICLE NO. RT961076	doi:10.1006/rtph.1996.1076. PMID 9056496.	1997

Practicals: Major

<table>
<tr><th>Course Code
23BUCH2P1</th><th>Course Title
Chemistry Practical</th><th>Credits
1</th><th>No. of lectures in hrs.</th></tr>
<tr><td colspan="4">Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to
• Be skillful in handling various glassware and instruments.
• Introduction of instruments used in chemical laboratory
• Actively participate in chemical laboratories
• Study of characterization of organic compounds.</td></tr>
<tr><td>1.</td><td colspan="2">Unit I: Physical Chemistry
1. To determine the rate constant for the saponification reaction between ethyl acetate and NaOH
2. To determine dissociation constant of weak acid (Ka) using Henderson’s equation and the method of incomplete titration pHmetrically.
3. To verify Beer-Lambert’s law, using KMnO4 solution by colorimetric method.
4. To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.</td><td rowspan="3">30</td></tr>
<tr><td>2.</td><td colspan="2">Unit II: Inorganic Chemistry
1. Qualitative analysis: (at least 4 mixtures to be analyzed)
Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.
Cations (from amongst):
Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^{+},NH^{4+}
Anions (From amongst):
$CO3^{2-}$, S^{2-}, SO^{2-}, $NO2^{-}$, $NO3^{-}$, Cl^{-}, Br^{3-}, I^{-}, $SO4^{2-}$, $PO4^{3-}$
(Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations.)
2. Redox Titration: To determine the percentage of copper(II) present in a given sample by titration against a standard aqueous solution of sodium thiosulfate (iodometry titration)</td></tr>
<tr><td>3.</td><td colspan="2">Unit III: Organic Chemistry
Characterization of organic compound containing C, H, (O), N, S, X elements.
(minimum 7 compounds)</td></tr>
</table>

Practicals: Minor

<table>
<tr><th>Course Code
23BUCH2P2</th><th>Course Title
Chemistry Practical</th><th>Credits
1</th><th>No. of lectures in hrs.</th></tr>
<tr><td colspan="4">Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to
• Be skillful in handling various glassware and instruments.
• Introduction of instruments used in chemical laboratory
• Actively participate in chemical laboratories
• Study of characterization of organic compounds.</td></tr>
<tr><td>1.</td><td colspan="2">Unit I: Physical Chemistry
1. To determine the rate constant for the saponification reaction between ethyl acetate and NaOH
2. To determine dissociation constant of weak acid (Ka) using Henderson’s equation and the method of incomplete titration pHmetrically.
3. To verify Beer-Lambert’s law, using KMnO4 solution by colorimetric method.
4. To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.</td><td rowspan="3">30</td></tr>
<tr><td>2.</td><td colspan="2">Unit II: Inorganic Chemistry
2. Qualitative analysis: (at least 4 mixtures to be analyzed)
Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.
Cations (from amongst):
Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^{+},NH^{4+}
Anions (From amongst):
$CO3^{2-}$, S^{2-}, SO^{2-}, $NO2^{-}$, $NO3^{-}$, Cl^{-}, Br^{3-}, I^{-}, $SO4^{2-}$, $PO4^{3-}$
(Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations.)
2. Redox Titration: To determine the percentage of copper(II) present in a given sample by titration against a standard aqueous solution of sodium thiosulfate (iodometry titration)</td></tr>
<tr><td>3.</td><td colspan="2">Unit III: Organic Chemistry
Characterization of organic compound containing C, H, (O), N, S, X elements.
(minimum 7 compounds)</td></tr>
</table>

References

Semester 2					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Senior Practical Physical Chemistry	B. D. Khosla	-	-	2011
2.	Vogel's *Quantitative Chemical Analysis*	J. Mendham	**Pearson**	**6th**	2009
3.	Practical Organic Chemistry	F.G. Mann,	Pearson Education	-	2009
4.	Textbook of Practical Organic Chemistry	A. I. Vogel	Prentice-Hall	**5th**	1996

Evaluation Scheme 20:30

Internals

Attendance	Group discussion	Assignments	Leadership qualities	Total
05	05	05	05	20
OR	Class test			
OR	Certification of Swayam / NPTEL in concern course			

Theory Examination: Suggested Format of Question paper

Duration: 1.30 Hours **Total Marks : 30**

All questions are compulsory

Q.1	**Attempt ANY TWO of the following**		**(10)**
(A)	Unit 1		
(B)	Unit 1		
(C)	Unit 1		
(D)	Unit 1		
Q.2	**Attempt ANY TWO of the following**		**(10)**
(A)	Unit 2		
(B)	Unit 2		
(C)	Unit 2		
(D)	Unit 2		
Q.3	**Answers the following (Attempt ANY TWO)**		**(10)**
(A)	**Fill in the blanks.**		
	i)	Unit 1	
	ii)	Unit 1	
	iii)	Unit 2	
	iv)	Unit 2	
	v)	Unit 2	
(B)	**Multiple choice questions.**		
	i)	Unit 1	
	ii)	Unit 1	
	iii)	Unit 1	
	iv)	Unit 2	

	v)	Unit 2	
(C)	**Match the following**		
	i)	Unit 1	
	ii)	Unit 1	
	iii)	Unit 2	
	iv)	Unit 2	
	v)	Unit 2	
(D)	**True and False**		
	i)	Unit 1	
	ii)	Unit 1	
	iii)	Unit 1	
	iv)	Unit 2	
	v)	Unit 2	

Marks Distribution and Passing Criterion for Each Semester

Semester 1 and Semester 2: Major and SEC

Theory				
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing
23BUCH 2T1	**20**	**08**	**30**	12
23BUCH 2T2	**20**	**08**	**30**	12
23BUCH 2P1	**-**	**-**	**50**	20
23BU2SEC7	Internal and external Theory + Practical		Theory + Practical 50 marks	20

Semester 1 and Semester 2: Minor

Theory				
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing
23BUCH 2T3	**20**	**08**	**30**	12
23BUCH 2T4	**20**	**08**	**30**	12
23BUCH 2P2	**-**	**-**	**50**	20

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