



પરિપત્ર:

ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટીની સાયન્સ વિદ્યાશાખાનાં અભ્યાસક્રમ ચલાવતી તમામ સંલગ્ન કોલેજોનાં આચાર્યશ્રીઓને સવિનય જણાવવાનું કે સાયન્સ વિદ્યાશાખા હેઠળનો કેમેસ્ટ્રી (એનાલિટીકલ) વિષયનો (એમ.એસસી. કેમેસ્ટ્રી (એનાલિટીકલ)) પ્રોગ્રામનો સેમેસ્ટર-૧ થી સેમેસ્ટર-૪ નો અભ્યાસક્રમ આ સાથે સામેલ છે.

માનનીય કુલપતિશ્રીની મંજૂરી અનુસાર સદર અભ્યાસક્રમ શૈક્ષણિક વર્ષ ૨૦૨૩-૨૪ થી અમલવારી કરવાની રહે છે. સાયન્સ વિદ્યાશાખાનાં કેમેસ્ટ્રી વિષયનાં પી.જી.નો અભ્યાસક્રમ ચલાવતી તમામ સંલગ્ન કોલેજોનાં પી.જી.સેન્ટર અને અનુસ્નાતક ભવનો દ્વારા તેની અમલવારી કરવા જણાવવામાં આવે છે.



[Signature]
06/07/2024
ખાસ ફરજ પરના અધિકારી
(એકેડેમિક)

ક્રમાંક/બીકેએનએમયુ/એકેડેમિક/૮૦૧/૨૦૨૪

ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી,

સરકારી પોલીટેકનિક કેમ્પસ,

ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી રોડ,

ખડીયા, જૂનાગઢ-૩૬૨૨૬૩

તા.૦૬/૦૭/૨૦૨૪

પ્રતિ,

- ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી સંલગ્ન સાયન્સ વિદ્યાશાખાનાં પી.જી.(કેમેસ્ટ્રી)નાં અભ્યાસક્રમો ચલાવતી તમામ કોલેજોના આચાર્યશ્રીઓ તેમજ સંલગ્ન ભવનનોનાં અધ્યક્ષશ્રીઓ તરફ....

નકલ સાદર રવાના:-

- માન.કુલપતિશ્રી/કુલસચિવશ્રીનાં અંગત સચિવશ્રી.
- પરીક્ષા નિયામકશ્રી, ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી, જૂનાગઢ

નકલ રવાના જાણ તથા યોગ્ય કાર્યવાહી અર્થે:

- સીસ્ટમ મેનેજરશ્રી, આઇ.ટી.સેલ વિભાગ (વેબસાઇટ ઉપર પ્રસિદ્ધ થવા અર્થે.)



**BHAKTA KAVI NARSINH MEHTA UNIVERSITY
JUNAGADH**



**BOARD OF CHEMISTRY STUDIES
FACULTY OF SCIENCE
SYLLABUS FOR
M.Sc. CHEMISTRY (ANALYTICAL) PROGRAMME
(SEMESTER- I - IV)
EFFECTIVE FROM A.Y. 2023-24**

Bhakta Kavi Narsinh Mehta University
Scheme of Instruction and Examinations
M. Sc. Chemistry
SEMESTER-I

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total /Passing	Total/ Passing	Total/ Passing	
1	PG	1	Core	Inorganic Chemistry	CC-101	4	4	30/12	70/28	--	-	100/40
2	PG	1	Core	Organic Chemistry	CC-102	4	4	30/12	70/28	-	-	100/40
3	PG	1	Core	Physical Chemistry	CC-103	4	4	30/12	70/28	-	-	100/40
4	PG	1	Core	Analytical Chemistry	CC-104	4	4	30/12	70/28	-	-	100/40
5	PG	1	Practical	Practical*	CP-105	6	12	-	-	-	100/40	100/40
6	PG	1	Practical	Practical Viva Voce	CP-106	1	-	-	-	-	50/20	50/20
7	PG	1	Skill Enhancement Course	Chemoinformatic Tools	CP-107	1	2	-	-	50/20	-	50/20
Total						24	30					600

***Practicals of SEM-1 includes Inorganic and physical chemistry.**

Bhakta Kavi Narsinh Mehta University
Scheme of Instruction and Examinations
M. Sc. Chemistry
SEMESTER-II

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total /Passing	Total/ Passing	Total/ Passing	
1	PG	2	Core	Inorganic Chemistry	CC-201	4	4	30/12	70/28	--	-	100/40
2	PG	2	Core	Organic Chemistry	CC-202	4	4	30/12	70/28	-	-	100/40
3	PG	2	Core	Physical Chemistry	CC-203	4	4	30/12	70/28	-	-	100/40
4	PG	2	Core	Analytical Chemistry	CC-204	4	4	30/12	70/28	-	-	100/40
5	PG	2	Practical	Practical*	CP-205	6	12	-	-	-	100/40	100/40
6	PG	2	Practical Viva Voce	Practical Viva Voce	CP-206	1	-	-	-	-	50/20	50/20
7	PG	2	Skill Enhancement Course	Research Writing	CP-207	1	2	-	-	50/20	-	50/20
Total						24	30					600

***Practicals of SEM-2 includes Organic and Analytical chemistry.**

Bhakta Kavi Narsinh Mehta University
Scheme of Instruction and Examinations
M. Sc. Chemistry (Analytical Chemistry)
SEMESTER-III

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total /Passing	Total/ Passing	Total/ Passing	
1	PG	3	Core	Pharmaceutical Regulatory Affairs-I	AC-301	4	4	30/12	70/28	--	-	100/40
2	PG	3	Core	Pharmaceutical Technology	AC-302	4	4	30/12	70/28	-	-	100/40
3	PG	3	Core	Instrumental Methods of Analysis	AC-303	4	4	30/12	70/28	-	-	100/40
4	PG	3	Core	Modern Spectroscopy	AC-304	4	4	30/12	70/28	-	-	100/40
5	PG	3	Practical	Practical & Viva Voce	AP-305	6	12	-	-	-	100/40	100/40
6	PG	3	Skill Enhancement Course	Research Project Proposal & Viva Voce	AP-306	2	4	-	-	-	100/40	100/40
Total						24	32					600

Bhakta Kavi Narsinh Mehta University
Scheme of Instruction and Examinations
M. Sc. Chemistry (Analytical Chemistry)
SEMESTER-IV

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total/ Passing	Total/ Passing	Total/ Passing	
1	PG	4	Core	Pharma Regulatory Affairs-II	AC-401	4	4	30/12	70/28	-	-	100/40
2	PG	4	Core	Separation Techniques	AC-402	4	4	30/12	70/28	-	-	100/40
3	PG	4	Dissertation/ Practical	Dissertation/ Project or Practical	AP-403	12	24	-	-	-	200/80	200/80
4	PG	4	Self-study	Dissertation/ Project Viva Voce or Practical Viva Voce	AP-404	4	-	-	-	-	100/40	100/40
Total						24	32					500

Program Outcomes (POs): M.Sc. Chemistry with Specialization in Organic/Analytical/Inorganic/Physical Chemistry

PO No.	PO detail
PO₁	Depth and breadth of knowledge: To produce efficient chemistry graduates with strong fundamental knowledge to cater the global needs related to chemical sciences.
PO₂	Research and scholarship: To develop research proficiency among graduates for the effective & practical solutions of industrial and societal issues.
PO₃	Practice and usage of modern technology: To inculcate technical skills in the chemistry graduates towards the use of modern & sophisticated instruments, equipments & cheminformatic tools.
PO₄	Professional capacity and passion of learning: To empower graduates for skilful utilization of the chemical literature to identify and address various problems by complying with environmental, ethical, and safety aspects.
PO₅	Moral and aesthetic sustainability: To enrich graduates with contemporary training in professional responsibility, ethics, lifelong learning to secure placement.

Program Specific Outcomes (PSOs): M.Sc. Chemistry with Specialization in Organic/Analytical/Inorganic/Physical Chemistry

PSO No.	PSO Statement
PSO₁	To understand the core chemistry and apply subjective knowledge for the qualitative or quantitative behaviour of compounds.
PSO₂	To demonstrate practical aspects in specialized area comprising Organic/Analytical/Inorganic/Physical chemistry.
PSO₃	To design and perform a broad variety of experiments related to chemistry.
PSO₄	To communicate scientific information orally and in writing.
PSO₅	To acquire ability towards usage of the techniques, skills, and modern tools necessary for chemistry domain.
PSO₆	To comprehend and apply chemical literature for research and effective problem solving.
PSO₇	To create advance skill for the evaluation of experimental results and extend the knowledge to develop competency.
PSO₈	To develop adaptability towards inter & multidisciplinary areas of chemical science.
PSO₉	To apply critical thinking for the environmental issues & sustainable development through chemistry research.
PSO₁₀	To inculcate the ability involving independent and life- long learning in context to societal needs.
PSO₁₁	To empower professional and ethical responsibility.

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-101	Inorganic Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Predict bonding & shapes of covalent compounds using MO & VB theories.	
2	Understand and predict the chemical and physical properties of S- block elements.	
3	Classify coordination compounds & predict isomerism, coordination number, shapes and spectral term symbol for coordination compounds.	
4	Explain labile and inert metal complexes with its mechanism.	
5	Outline theoretical and practical aspects of nano materials.	

SEMESTER-I				
CC-101		Inorganic Chemistry	4 hrs./Wk	4 Credits
Sr. No.	Course Detail			Inst. Hrs.
Unit.1	Atomic Model & Bonding Atomic Model, Structure & Bonding, Bond Parameters, Molecular orbital theory, Homonuclear diatomic molecules, Heteronuclear diatomic molecules, Valance bond theory, Types of overlapping, Shapes of covalent compounds, VSEPR, Shapes of molecules having regular & irregular geometry, bent's rule.			12
Unit.2	Main Group (S-Block) Chemistry of Main group Elements of S-Block, General Trends, Physical and Chemical Properties and selected Applications.			10
Unit.3	Coordination Compounds Classification of Coordination compounds, Werner’s theory, Nomenclature, Isomerism, Coordination number, structures, shapes and Hybridisation, electronic spectra, spectroscopic terms, term symbols, calculation of spectroscopic terms.			14
Unit.4	Reaction Mechanism of Coordination Compounds Synthesis and reactions of coordination compounds, Labile and inert complexes, Types of reactions in metal complexes, Substitution in square planar complexes, Substitution reactions & mechanism in octahedral complexes, Trans effect.			12
Unit.5	Nanomaterial Definition and Introduction of nanomaterial, Size effects, Importance of nanomaterials, Classification of nanomaterials, Properties of nanomaterial, Synthesis techniques of nanomaterials, Inorganic Nanoparticles and Nano porous Materials: Oxide, catalysis. Techniques for characterisation of nanoscale materials: SEM, TEM, XRD, AFM.			12

Reference Books

1. Miessler, G. L; Fischer, P. J.; Tarr, D. A.; (2014, sixth edition) Inorganic Chemistry, (ISBN: 978-0-321-81105-9).
2. Agarwala S. K.; Lal K.; (2009), Advanced Inorganic Chemistry, (ISBN: 978-81-8398-773-8).
3. Singh, A.; Singh, R.; (2005) Textbook of Inorganic Chemistry Vol. I & II. New Delhi: Campus Books International, (ISBN: 8180300714).
4. Housecroft C. E; Sharpe A. G.; (2005, 2nd edition) Inorganic Chemistry, (ISBN: 0130-39913-2).
5. House J. E; House K. A.; (2016, 3rd edition) Descriptive Inorganic Chemistry, (ISBN: 978-0-12-804697-5).
6. Rao C. N. R; Muller A.; Cheetam A. K.; (2004) The Chemistry of Nanomaterials, Vol.1, and 2, Wiley – VCH.
7. Poole C. P.; Owens Jr. F. J.; (2003) Introduction to Nanotechnology Wiley Interscience.
8. Kenneth J. K. (2001) Nanoscale materials in Chemistry, Wiley Interscience.
9. Pradeep T.; (2007) Nano: The Essentials in understanding nanoscience and nanotechnology, Tata McGraw Hill.
10. Ajaikumar; (2016 2nd edition) Organometallic & Bioinorganic Chemistry, Aaryush Education, (ISBN:978-81-930437-1)
11. Strohfeldt K. A., (2015) Essentials of inorganic chemistry: for students of pharmacy, pharmaceutical sciences and medicinal chemistry, (ISBN: 9780470665589)

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-102	Organic Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand the concept of various electronic effect and its applications.	
2	Calculate aromaticity and differentiate between aromatic, anti-aromatic and non-aromatic compounds.	
3	Understand concept and types of reaction mechanism, draw arrow notation, categorize bond cleavages, and generation of reactive intermediates.	
4	Explain reaction mechanism and identify the reagent for the C-C bond forming reactions.	
5	Illustrate preparation of organic reagents and recognize appropriate reagent for particular reaction.	

SEMESTER-I			
CC-102	Organic Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Reactive Organic Intermediates Inductive effect, Resonance effect, Hyperconjugation effect and its applications (Stability, Acidity, Basicity, Nucleophilicity, Aromatic character), Homolytic and Heterolytic fission, Different types of arrow notation, concept and Examples of Electrophiles and Nucleophiles. Hybridization, Structure, Generation, Stability, Reactivity & Applications of Carbocation, Carbanion, Free radicals, Carbenes, Nitrenes, Ylides, Benzyne and Enamines. Applications and related reactions Aromaticity Introduction, Criteria of aromaticity, Hückel's rule, Examples of aromatic, anti-aromatic and non-aromatic compounds. Aromatic character for Annulenes, Azulenes & Heterocycles.	14	
Unit.2	Organic Reactions Principal, mechanism and applications of: Appel reaction, Benzoin condensation, Nef reaction, Prins reaction, Mitsunobu reaction, Vilsmeier-Haack reaction, Blanc Reaction, Riemer-Tiemann, Michael addition, Dieckmann condensation, Robinson annulations, Arndt-Eistert, Corey-Fuchs alkyne synthesis, Nazarov cyclization.	10	
Unit.3	Rearrangements Principal, mechanism and applications of: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Beckmann, Schmidt, Baeyer-Villiger, Lossen rearrangement, Neber rearrangement, Baker-Venkataraman rearrangement	10	
Unit.4	Conjugate addition & C-C Bond Forming Reactions Enolate, Enamine and Imine chemistry, Grignard reagents, Cuprates and other conjugate reactions.	14	

	Olefination reaction: Wittig, Horner–Wadsworth–Emmons, Mc-Murry reaction. Cyclopropanation reaction (Simons-smith), Bayliss Hillman reaction, Organocatalyzed C-C bond forming reactions: Aldol reaction, Mannich reaction and Stork enamine synthesis.	
Unit.5	Organic Reagents General mechanism, selectivity, and important applications of the following reagents: (a) Oxidative Reagents: $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3 -pyridine (Collin's reagent), hypervalent iodine reagents (Dess-Martin), Swern reagent, SeO_2 , HIO_4 , $NaIO_4$ (b) Metal hydride reduction: Boron reagents ($NaBH_4$, 9-BBN), aluminium reagents ($LiAlH_4$, DIBAL-H), Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	12
Reference Books 1. Ahluwalia, V. K. (2011, Fourth edition) Organic Reaction Mechanism. New Delhi: Narosa (ISBN: 978-81-8487-115-9). 2. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1st Ed., Oxford University Press, 2001. 3. László Kürtip; Barbara Czako (2004, First edition) Strategic Applications of Named Reaction in Organic Synthesis. Philadelphia: Elsevier Publishing company (ISBN: 9780124297852). 4. M.B. Smith & J. March, March's Advanced Organic Chemistry, 6thEd., John Wiley & Sons, New York, 2007. 5. F.A. Carey and R.A. Sundberg, Advanced Organic Chemistry, Part A and Part B, 5th Ed., 6. McMurry, John E. (2011, Eight edition) Organic Chemistry. Boston: Cengage Learning (ISBN: 0840054440). 7. Smith, Michael B.; March, Jerry (2013, Seventh edition) March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure. Hoboken: Wiley-Blackwell (ISBN: 978-0-470-46259-1). 8. Bansal, Raj K. (2009, Fifth) A Textbook of Organic Chemistry. New Delhi: New Age International (ISBN: 978-81-224-2025-8). 9. T. W. Graham Solomons (2011, 10th edition) Organic Chemistry. Hoboken: John Willey & Sons (ISBN: 978-0-470-55659-7).		

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-103	Physical Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand thermodynamics of particle by statistical approach, derive and calculate thermodynamic properties of mono and diatomic molecules	
2	Understand the theories of electrochemical properties with numerical problems	
3	Justify ideal & non-ideal solutions and determination of properties of solutions	
4	Distinguish Free energy change and its applications in chemical reactions	
5	Classify the types, characteristics and mechanism of homogeneous & heterogeneous catalysis.	

SEMESTER-I			
CC-103	Physical Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Statistical Thermodynamics: The concepts of Ensemble, Thermodynamic probability and entropy, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Partition function, Molar partition function, Thermodynamic properties in term of molecular partition function for diatomic molecules, Monoatomic gases, Rotational, Translational, Vibrational and Electronic partition functions for diatomic molecules. Problems.	14	
Unit.2	Electrochemical cells Introduction, Ostwald dilution law, Debye-Huckel theory of mean ionic activity coefficients, Decomposition potential and its determination, over voltage, hydrogen over voltage, factors affecting over voltage, importance of hydrogen over voltage, Tafel equation. numerical problems. Commercial cells: Fuel cell, lead accumulator, nickel iron accumulator, zinc silver accumulator.	10	
Unit.3	The Properties of Solutions Ideal solutions: Properties, the Duhem-Margules equation, vapour pressure curves. Composition of liquid and vapour in equilibrium influence of temperature on gas solubility and solid-liquid equilibria. Non ideal solutions: Deviation from ideal behavior, vapour pressure curves, liquid and vapour compositions. General equations for liquid mixtures, Dilute solutions: Henry's law. Determination of molecular weights from freezing and boiling points. Problems.	12	
Unit.4	Free Energy and Chemical Reactions Chemical equilibrium and the equilibrium constant: Equilibrium in homogeneous gaseous systems. Homogeneous reactions in liquid solutions. Homogeneous reactions in dilute solutions. Chemical equilibria in heterogeneous systems.	14	

	Free energy change in chemical reactions: The reaction isotherm, standard free energy of reaction, the direction of chemical variation of equilibrium constant with pressure and temperature. Influence of temperature on heterogeneous reactions. Integration of the Van't Hoff equation. Variation of standard free energy with temperature, problems.	
Unit.5	Catalysis • Introduction, Types of catalysis (Homogeneous & heterogeneous), comparison between them, general characteristics of catalytic reaction. • Heterogeneous catalysis: kinetics of unimolecular and bimolecular surface reaction. • Homogeneous catalysis: types of acid base catalysis, Mechanism and kinetics of acid-base catalysis • Enzyme catalysis- Mechanism and kinetics of enzyme catalysed reaction. • Nanocatalysis, types, applications.	10
Reference Books 1. Glasstone, Samuel. (2007) Textbook of Physical Chemistry: MCMILAN India Press (SBN: 033391-876-2). 2. Peter Atkins, Julio de Paula (2015) Physical chemistry: Thomson Press (ISBN: 019872872-7). 3. Gurdeep Raj (2014, Third edition) Thermodynamics. Meerut: GOEL publishing House (ISBN: 8187224886). 4. Gurtu, J. N. Gurtu,A. (2014, Twelfth edition) Advanced Physical Chemistry. Meerut: Pragati Prakashan (ISBN: 9350060191). 5. Barrow, Gordon M. (1996, Sixth edition) Physical Chemistry. New York: McGraw-Hill International. (ISBN: 0070051119). 6. V R Gowariker, (2012) Polymer Chemistry. New age International P limited. (ISBN: 978-0-85226-307-5). 7. Puri, Sharma, Pathamia, (2018, 47th edition) Principles of Physical Chemistry. Vishal Publishing Co. (ISBN: 978-93-82956-78-5). 8. B. S. Bahl, Arun Bhahl,G. D. Tuli, (2005) Essetials of Physical Chemistry. S. Chand & Company LTP. (ISBN: 81-219-0546-X). 9. Physical Chemistry, Ira N Levine (Tata McGraw-Hill Publishing Company, New Delhi, Fifth Edition). 10. Physical Chemistry, Alberty and Stilby, (John Wiley & Sons, New York). 11. D.K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age, 2008. 12. Introduction to the principles of heterogeneous catalysis. J.M.Thomas and W.J.Thomas, Acad.press, London, 1967. 13. Chemical kinetics and catalysis G.M.Panchenkov and V.P.Lebedev., Mir publication, 1976.		

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-104	Analytical Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand basic concepts of analytical techniques	
2	Apply various traditional analytical methods for chemical analysis.	
3	Identify principles and applications of green chemistry	
4	Discuss optical methods and apply for chemical analysis	
5	Explain thermal methods and apply for thermal analysis	

SEMESTER-I			
CC-104	Analytical Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Fundamentals of Analytical Chemistry & Chemical Calculations Analytical chemistry, its functions and applications, Analytical problems and procedures, Analytical techniques and methods, Concentration units (Molarities, Normality, Formality, ppb, ppm, mole calculation, Empirical Formulas, % composition, Determination of molecular weight, theoretical yield, Percent Yield, Problems	12	
Unit.2	Analytical Methods Solution equilibria, Electrochemical reactions, Potentiometry, pH and its control, Titrimetry I: acid–base titrations, Complexation, solubility and redox equilibria, Titrimetry II: complexation, precipitation and redox, titrations, Gravimetry, Voltammetry and amperometry, Conductimetry	10	
Unit.3	Green Chemistry Introduction, importance and twelve principles of Green Chemistry. Designing a green synthesis using these principles. Green Chemistry in day to day life. Green solvents (alternatives of organic solvents). Ionic liquids, supercritical fluids, CO ₂ and H ₂ O and aqueous phase organic synthesis. Non-traditional greener alternative approaches: green reagents, catalysis, biocatalysis. Applications of non-conventional energy sources: Microwave, ultrasonic assisted synthesis, electro-synthesis and sunlight (UV), radiation assisted synthesis.	14	
Unit.4	Optical Methods Refractive index: Introduction, Principle, Instrumentation, Measurement of refractive index, abbe refractometer, immersion refractometer, application. Polarimetry: Introduction, Principle, Instrumentation, optical purity, calculations.	12	
Unit.5	Thermal Methods of Analysis Principle, theory and instrumentation of TGA, DTA and DSC. Factors affecting thermal analysis. Applications of thermal methods in various field of science. Various theories of thermal analysis for evaluation of kinetic parameters and analysis of simple and polymeric compounds.	12	

Reference Books

1. Fundamentals of Analytical Chemistry by Skoog Douglas A.
2. Analytical Chemistry by D. Kealey & P. J. Haines, BIOS Scientific Publishers Limited, 2002
First published 2002 (ISBN 1-85996-189- 4)
3. Instrumental Methods of Analysis by B. Sivasankar,
4. B. K. Sharma. "Instrumental method of chemical analysis" 24th edition, GOEL publishing
house Meerut .2005
5. Gary D. Christian. "Analytical chemistry" 6th edition John Wiley & sons, Inc. 2004
6. Skoog, Holler, Niemon, "principles of instrumental analysis" 5th edition, Saunders college
publisher.
7. Analytical Chemistry by Chatwal G. R.
8. Indian Pharmacopoeia Commission (IPC) Ghaziabad, www.ipc.gov.in
9. Green Chemistry by V. K. Ahluwalia, Ane Books Pvt. Ltd.
10. Green Chemistry by K. R. Desai, Himalia Publishing House. Instrumental Methods of Analysis
by B. Sivasankar,
11. B. K. Sharma. "Instrumental method of chemical analysis" 24th edition, GOEL publishing
house Meerut .2005
12. Gary D. Christian. "Analytical chemistry" 6th edition John Wiley & sons, Inc. 2004
13. Skoog, Holler, Niemon, "Principles of instrumental analysis" 5th edition, Saunders college
publisher.
14. Analytical Chemistry by Chatwal G. R.
15. Analytical Chemistry: Theory and Practice by Verma R. M.

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CP-105	Practical	6 Credits & 12 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Perform qualitative analysis of an inorganic mixture containing six radicals.	
2	Perform inorganic complex synthesis and its characterization.	
3	Utilize Conductivity meter, pH & Potentiometer, Refractometer and Polarimeter for physicochemical analysis.	
4	Perform experiments on Partition Co-efficient, First and second order reactions-order determination, energy of activation, Heat of vaporization.	
5	To examine adsorption isotherms.	

SEMESTER-I			
CP-105	Practical	12 hrs./Wk	6 Credits
SR. No.	Practical Detail	Lab Hours	
1	Inorganic Chemistry Practical (50 Marks)	6	
	1. Inorganic Qualitative Analysis (25 Marks) Analysis of a mixture containing six radicals including one less common metal ion: W, Tl, Ti, Mo, Se, Zr, Th, Ce, V and Li. (Minimum 10 mixtures) 2. Preparation and Characterisation of metal complexes (25 Marks): 1. Preparation and Characterisation of $[\text{VO}(\text{AcAc})_2]$. 2. Preparation of cis & trans $[\text{Cr}(\text{Ox})_2(\text{H}_2\text{O})]$. 3. Preparation and Characterisation of $[\text{Co}(\text{Py})_2\text{Cl}_2]$. 4. Preparation of $[\text{Cu}(\text{gly})_2]$ & $[\text{Cu}(\text{acac})_2]$. 5. Preparation and Characterisation of $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$ 6. Preparation and Characterisation of $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ compare with $[\text{Ni}(\text{H}_2\text{O})_6]\text{Cl}_2$. 7. Preparation and Titrimetric Estimation of $[\text{Fe}(\text{HCO}_2)_2] \cdot 2\text{H}_2\text{O}$. 8. Preparation and Characterisation of $[\text{Ni}(\text{en})_3]\text{Cl}_2 \cdot 2\text{H}_2\text{O}$ 9. Synthesis of bis(salicylidene)ethylene diamine cobalt (II) complex. 10. Synthesis of bis(8-quinolinol) bis(benzylidene)ethane-1,2-diamine Ni(II) complex.		
	Physical Chemistry Practicals (50 Marks)		
2	Group-A (25Marks): Conductometry: 1. To determine concentration of mixture $\text{HCl} + \text{CH}_3\text{COOH} + \text{CuSO}_4 / \text{HCl} + \text{Oxalic acid}$ vs $\text{NH}_4\text{Cl} / \text{NaOH}$ by conductometrically. 2. To determine the equivalent conductance of a strong electrolyte and to verify the Onsager's equation. 3. To determine the degree of hydrolysis and hydrolysis constant. 4. Determine the CMC of a surfactant by conductivity measurements.	6	

	5. To determine the Equivalence conductance and dissociation constant of strong electrolytes and weak electrolytes and hence to verify Ostwald's distribution law. pH metry: 1. To determine normality and dissociation constant of tribasic acids using 0.1N NaOH by pH metrically 2. To determine the Hammett constant for p-amino/ nitro benzoic acid using 0.1N NaOH by pH metry. 3. To determine the standard oxidation potential of the Quinhydrone electrode. 4. To determine the acidic and basic dissociation constants of amino acid and its isoelectric point by pH metry. 5. Determine the dissociation constant and strength of borax solution pH-metrically. Potentiometry: 1. Determination of dissociation constant of dibasic acids. 2. Determination of activity and activity coefficient of ions. 3. Redox titration Fe^{+2} vs Ce^{+4}, I^- vs KMnO_4. 4. Determine the amount of ferrous sulphate/ferrous ammonium sulphate in given flask potentiometrically using ceric salt solution. 5. Determine the pseudo first order rate constant for bromination of N, N – dimethylaniline/phenol. Refractometry: 1. To study the variation of refractive index with composition of given liquid and to determine the % composition of unknown mixture. 2. Determine parachor/density/refractive index of binary solutions. 3. To determine the molar refractive index of a given salt. 4. To determine the electron polarization and electron polarizability of a given salt. 5. To determine refraction equivalents of carbon, hydrogen and chlorine atoms.	
	Group-B (25 Marks) Partition Co-efficient: 1. To study the distribution of benzoic acid between toluene & water at room temperature and hence to prove the dimerization of benzoic acid in benzene / toluene. 2. To determine equilibrium constant for the reaction between potassium iodide& iodine by the method of distribution. 3. Determine the formula of a complex between Cu^{+2} and NH_3 by distribution method. 4. Determine the equilibrium constant of the reaction $\text{I}^- + \text{I}_2 = \text{I}_3^-$ by the distribution method. 5. To study the distribution co-efficient of succinic acid between ether and water.	

	Reaction Kinetics: 1. To determine the order of the reaction by a fractional change method. 2. To determine the temperature coefficient and the energy of activation of the reaction between KBrO_3 and KI. 3. Autocatalytic reaction between KMnO_4 and oxalic acid 4. To determine the reaction velocity constant for the reaction between acetone & iodine 5. To determine the temperature coefficient and energy of activation of hydrolysis of methyl acetate catalyzed by $\text{HCl} + \text{KI}$ by fractional change method. Adsorption: 1. To study the adsorption of aqueous oxalic acid solution by activated charcoal and examine the validity of Freundlich and Langmuir's adsorption isotherms. 2. To study the adsorption of I_2 from alcoholic solution by charcoal. Polarimetry: 1. To determine the specific & molecular rotation of glucose/ sucrose & hence intrinsic rotation and concentration of an unknown solution of optically active compound. 2. To determine the rate constant for the inversion of cane sugar. 3. To determine % composition of D-sucrose and tartaric acid in a given mixture. Thermodynamics 1. Heat of vaporization: To determine heat & entropy of vaporization of a given liquid by a kinetic approach.	
Reference Books 1. Svehla, G. (1996, Seventh edition) Vogel's Qualitative Inorganic Analysis. New Jersey: Pearson Education. (ISBN: 0582218667). 2. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989) Vogel's Textbook of Quantitative Chemical Analysis. Hoboken: John Wiley & Sons (ISBN: 0-582-44693-7). 3. Pass G., Sutcliffe H., (1974 2nd edition) Practical Inorganic Chemistry: Preparations, Reactions, and Instrumental Methods. (ISBN: 9789401727440) 4. Marusak R. A., Doan K., Cummings S. D., (2007) Integrated approach to coordination chemistry an inorganic laboratory guide, (ISBN: 9780471464839) 5. Woollins D. (2006, 2nd edition) Inorganic Experiments, (ISBN: 978352730510) 6. Parsania P. H (2005, 1st edition) Experiments in Physical Chemistry, Granth Nirman Board. 7. Experimental Physical Chemistry by G. Peter Matthews, (Clarendon Press, Oxford, London). 8. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, (New Age International Publishers, New Delhi). 9. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, (Pragati Prakashan, Meerut). 10. Advanced Physico-Chemical Experiments by J. Rose, (Sir Isaac Pitman & Sons Ltd., London). 11. Experiments in Physical Chemistry by D. P. Shoemaker, C. W. Garland and J. W. Nibler, (McGraw Hill International Edition, London) 12. A Laboratory Manual of Experiments in Physical Chemistry by D. Brennan and C. F. H. Tipper, (McGraw hill Publishing Company Ltd., London).		

13. Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, (Anjali Publication, Aurangabad)
14. Experimental Physical Chemistry by R. C. Das & B. Behera, (Tata McGraw hill Publishing Company Ltd., New Delhi).
15. W. J. Popiel, Laboratory Manual of Physical Chemistry, ELBS, London, 1970

M.Sc. Chemistry SEMESTER-I			
CP-106	Viva Voce	-	1 Credits
Comprehensive viva voce based on practical and core courses.			

SEMESTER-I		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CP-107	Chemoinformatic Tools	1 Credits & 2 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Draw structures, chemical reaction, mechanism & experimental assemblies.	
2	Generate IUPAC nomenclature from structures & vice versa	
3	Use MS Excell for data analysis and graphical representation	
4	Search & retrieve authenticated scientific reference materials.	

SEMESTER-I			
CP-107	Chemoinformatic Tools	2 hrs./Wk	1 Credits
1. Chemical Drawing - Drawing chemical reaction, Structure drawing using templates, Structure to name and name to structure. - Drawing mechanism of reaction, Diagram of Assembly, Chiral Structure. - Reproducing reaction scheme from given research paper, 3D Chemdraw ultra. - Use of MS Excel for plotting and statistical analysis. 2. Web & Tools for Literature Search - Research Journals & publications. 3. Citation & Referencing			

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-201	Inorganic Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Classify organometallic compounds using ligands, calculate oxidation state and determine hapticity.	
2	Categorize organometallic reaction mechanism and discuss catalytical cycles.	
3	Understand and predict the chemical and physical properties of P- block elements	
4	Discuss the classification and role of metal ions in function of biomolecules.	
5	Outline applications of various metal and radioactive isotopes in pharmaceutical chemistry.	

SEMESTER-II			
CC-202	Inorganic Chemistry	4 hrs./Wk	4 Credits
Sr. No.	Course Detail	Inst. hrs.	
Unit.1	Structure and Bonding in Organometallic Compounds Introduction, Structure & Classification, 18 Electron rule, Hapticity, Ligands in organometallic chemistry: carbonyls, nitrosyls, hydride and dihydrogen, phosphine, ethylene, and related ligands, cyclopentadiene and related ligands, alkyl, aryl, carbenes, carbynes, carbides.	14	
Unit.2	Reaction Mechanism and catalytic process of organometallic complex Reactions involving gain or loss of ligands, Ligand dissociation and substitution, Oxidative addition and C-H bond activation, Reductive elimination, and Pd-Catalyzed cross-coupling, Sigma bond metathesis, Organometallic catalysts: Catalytic deuteration, Hydroformylation, Monsanto acetic acid process, Tennessee–Eastman acetic anhydride process, Wacker (Smidt) process, Hydrogenation by Wilkinson’s catalyst, Olefin metathesis, Fischer–Tropsch carbon chain growth, Ziegler–Natta polymerizations.	12	
Unit.3	Main Group (P-Block) Chemistry of Main group Elements General Trends in Main Group Chemistry, Physical Properties, Electronegativity, Ionization Energy, Chemical Properties. selected Applications (Inorganic Polymers).	14	
Unit.4	Bioinorganic Chemistry Bio-Inorganic Chemistry Introduction, classification of elements according to their action in the biological system, deficiency, and toxicity, metalloenzymes: classification of biomolecules containing metal ions, metalloporphyrin: introduction, characterization of porphyrins, oxygen carrier and storage, hemoglobin (Hb) and myoglobin (Mb) in oxygen transfer mechanism & functions, biological electron transport proteins: iron-sulfur protein and cytochromes	10	
Unit.5	Selected Topics Inorganic Pharmaceutical Chemistry	10	

	Introduction, Alkali and Alkaline earth metals as drug, pharmaceutical application of boron and aluminium compounds, transition metal complexes as potential medicinal agent, Radioactive compounds and their clinical applications, Chelation therapy.	
Reference Books 1. Miessler, G. L; Fischer, P. J.; Tarr, D. A.; (2014, sixth edition) Inorganic Chemistry, (ISBN: 978-0-321-81105-9). 2. Agarwala S. K.; Lal K.; (2009), Advanced Inorganic Chemistry, (ISBN: 978-81-8398-773-8). 3. Singh, A.; Singh, R.; (2005) Textbook of Inorganic Chemistry Vol. I & II. New Delhi: Campus Books International, (ISBN: 8180300714). 4. Housecroft C. E; Sharpe A. G.; (2005, 2nd edition) Inorganic Chemistry, (ISBN: 0130-39913-2). 5. House J. E; House K. A.; (2016, 3rd edition) Descriptive Inorganic Chemistry, (ISBN: 978-0-12-804697-5). 6. Rao C. N. R; Muller A.; Cheetam A. K.; (2004) The Chemistry of Nanomaterials, Vol.1, and 2, Wiley – VCH. 7. Poole C. P.; Owens Jr. F. J.; (2003) Introduction to Nanotechnology Wiley Interscience. 8. Kenneth J. K. (2001) Nanoscale materials in Chemistry, Wiley Interscience. 9. Pradeep T.; (2007) Nano: The Essentials in understanding nanoscience and nanotechnology, Tata McGraw Hill. 10. Ajaikumar; (2016 2nd edition) Organometallic & Bioinorganic Chemistry, Aaryush Education, (ISBN:978-81-930437-1) 11. Strohfeldt K. A., (2015) Essentials of inorganic chemistry: for students of pharmacy, pharmaceutical sciences and medicinal chemistry, (ISBN: 9780470665589)		

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-202	Organic Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand concept, types and mechanism of multicomponent reaction with applications	
2	Apply C-C bond forming reactions using Pd- catalysis and illustrate its mechanism.	
3	Explain concept of organic photochemistry, properties of photochemical reactions and differentiate photo-induced cleavages.	
4	Understand fundamentals of stereochemistry and distinguish types of isomerism.	
5	Illustrate preparation of organic reagents and recognize appropriate reagent for particular reaction.	

SEMESTER-II			
CC-202	Organic Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Multicomponent Reactions Principle, mechanism and applications of: Biginelli, Hantzsch dihydropyridine, Mannich reaction, Doebner Quinoline Synthesis, Passerini reaction, Ugi, Malononitrile & 1,3-dicarbonyl based multicomponent reactions (chromenes and pyridine synthesis).	12	
Unit.2	Pd-catalyzed Cross-Coupling Reactions Introduction, Pd-catalysis, Various ligands, General mechanism of Cross-coupling. Principle, reaction mechanism and application of: Suzuki, Sonogashira, Heck, Negashi, Kumada, Stille, Buchwald-hartwig cross-coupling reactions.	12	
Unit.3	Photochemical Reactions Absorption of light by organic molecules, Jablonski diagram, properties of excited states, mechanism of excited state processes and methods of preparative photochemistry. (a) Photochemistry of alkenes and related compounds: Isomerization, Di- π -methane rearrangement and Cycloaddition (b) Photochemistry of carbonyl compounds: Norrish type-I cleavage of acyclic, cyclic, and unsaturated carbonyl compounds, Norrish type-II cleavage (c) Photocyclo-addition of ketones with unsaturated compounds: Paterno-Buchi reaction, Barton reaction, Photodimerisation of unsaturated ketones, Rearrangement of enones and dienones, Photo-Fries rearrangement.	14	
Unit.4	Fundamentals of Stereochemistry Isomerism, tetrahedron geometry and concept of chirality, Isomers, Classification of stereoisomerism, Optical isomerism due to tetrahedron carbon, Wedge-dash and Fisher Projections and their interconversion. Concept of enantiomers, diastereomers and meso compound. Various types of configurational	10	

	nomenclature of stereocenters (one, two similar and two dissimilar stereocenters). Ring and □ and diastereoisomerism-Variou methods of nomenclature for acyclic and cyclic systems-cis-trans, E-Z, syn and anti.	
Unit.5	Important Organic Reagents: General mechanism, selectivity, and important applications of the following reagents: TEMPO, NBS, n-Bu ₃ SnH(TBTH), DDQ, TBAB, DCC, Wilkinson catalyst, Azobisisobutyronitrile(AIBN), Organosilicon reagents (TMSCl, TMSCN, Arylsilanes, Hydrosilation).	12
Reference Books 1. László Kürtip; Barbara Czakó (2004, First edition) Strategic Applications of Named Reaction in Organic Synthesis. Philadelphia: Elsevier Publishing company (ISBN: 9780124297852). 2. Kalsi, P. S. (2012, Fourth edition) Organic Reactions Stereochemistry and Mechanism (Through Solved Problems). New Delhi: New Age International (P) Limited. (ISBN: 9788122417661). 3. Pericyclic reaction and organic photochemistry. V.P sharma and Rakesh Kumar (ISBN No. : 978-81-8398-632-8) 4. Organic Chemistry (VI edition) - R.T Morrison- Boyd. Prentice Hall of India (2003) 5. Organic Chemistry- (V edition) - John McMurry), Asian Book Pvt Ltd, New Delhi 6. Advanced organic chemistry (IV edition) - Jerry March 7. Basic stereochemistry of organic molecules by Subrata Sen Gupta, Oxford University press, (ISBN-10:0-19-945163-X) 8. Ahluwalia, V. K. (2011, Fourth edition) <i>Organic Reaction Mechanism</i>. New Delhi: Narosa (ISBN: 978-81-8487-115-9).		

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-203	Physical Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Outline polymers and explain various polymerization reactions	
2	Differentiate chain polymerization reactions and calculate polymer properties.	
3	Discuss types of crystals and point defects	
4	Explain adsorption isotherms and factors affecting it. Discuss properties of colloidal system and factor affecting it.	
5	Describe kinetics of complex reaction of unimolecular and photochemical reactions.	

SEMESTER-II			
CC-203	Physical Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Polymer Chemistry Introduction, addition and substitution reaction, Cyclization reaction, cross linking reaction, reactions leading to graft and block copolymers, miscellaneous reactions. Stereo regular polymers. Polymer nomenclature. Polycondensation Reaction route of poly functional compounds. Kinetics of polycondensation reaction. Molecular weight control in polycondensation. Statistics of linear polycondensation. Effect of monomer concentration and temperature on direction of polycondensation reaction.	12	
Unit.2	Chain Polymerization (a)Free Radical Polymerization: Methods of initiating free radical polymerization. Chain transfer reactions. Kinetics of free radical polymerization and chain transfer reactions. (b)Ionic (Catalytic) Polymerization: Kinetics of cationic and anionic polymerization. Coordination polymerization. Copolymerization and its kinetics. Evaluation of reactivity ratios. (c)Polymer molecular weight; number average molecular weight, the weight average molecular weight. Problems	12	
Unit.3	Solid state Introduction: symmetry of crystal, miller indices, Types of crystals:- molecular, Network covalent, ionic, metallic, band theory, energy band theory of conductors, semiconductors and insulators, imperfections in crystal-point defect, Schottky defect, Frenkel defect, metal excess defect, line defects, quasicrystals.	10	
Unit.4	Surface Chemistry Introduction, Adsorption isotherm: Freundlich, Langmuir, Gibbs and BET of multilayer adsorption, Surface area determination, Electrokinetic (Zeta) potential and its determination by electrophoresis, factor affecting zeta potential.	12	

	Colloidal state: General properties of colloidal system, Lyophobic sols and lyophilic sols, Surface active agent, Micellization: mechanism, Critical Micellar Concentration (CMC) factors affecting the CMC of surfactants.	
Unit.5	Chemical Kinetics: Introduction, activated complex theory in terms of thermodynamic, influence of ionic strength and solvent properties on rate, Complex reactions: Opposing reactions, Consecutive reactions, kinetics of fast reaction, Ionic reactions, and salt effect. Unimolecular reactions: Lindemann-Christiansen hypothesis, Hinshelwood. Photochemical reactions: introduction, rate law, kinetics of photochemical reactions- kinetics of hydrogen-bromine, decomposition of HI and Anthracene reaction.	14

Reference Books

1. Textbook of polymer science-third edition by Fred.W. Billmeyer Jr., a Willey Inter-science publication, ISBN-9971-51-141-X.
2. Polymer Science by V. R. Govariker, New age international publisher, ISBN:978-0-85226-307-5.
3. Glasstone, Samuel. (2007) *Thermodynamics for Chemists*: Narahari Press (ISBN: 1406773220).
4. Peter Atkins, Julio de Paula (2015) *Physical chemistry*: Thomson Press (ISBN: 019872872-7).
5. Gurdeep Raj (2014, Third edition) *Thermodynamics*. Meerut: GOEL publishing House (ISBN: 8187224886).
6. Gurtu, J. N. Gurtu,A. (2014, Twelfth edition) *Advanced Physical Chemistry*. Meerut: Pragati Prakashan (ISBN: 9350060191).
7. Chemical Kinetics, K. J. Laidler, (McGraw Hill Publication).
8. Advanced Practical Physical Chemistry by J. B. Yadav, (Goel Publishing House, Meerut).
9. Chemical Kinetics and Dynamics; Jeffrey I Steinfeld, Joseph S. Francisco and William L. Hase. Prentice Hall, 2nd edition, 1998.
10. Laidler, K. J.; "Chemical Kinetics", 3rd Edition 1997, Benjamin-Cummings. Indian reprint - Pearson 2009.
11. R.G.Frost and Pearson, Kinetics and Mechanism, Wiley, New York,1961.
12. G.A. Somorjai, Y. Li, Introduction to Surface Chemistry and Catalysis (2n ed.), 2010. Surface Chemistry: Theory and Applications by J.J Bikertman, Academic Press, New York (1972).
13. Physics at surfaces, A Zangwill, Cambridge university Press (1988).
12. Surface crystallography, L J Clarke, Wiley-Interscience (1985).
14. A.W. Adamson, A.P. Gast, Physical chemistry of surfaces, Wiley, 1997.
15. Surface crystallography, L J Clarke, Wiley-Interscience (1985)

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CC-204	Analytical Chemistry	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Justify method validation parameters and statistical significance of test	
2	Understand the different criteria of Intellectual Property rights and its legislations	
3	Illustrate pharmacopeial analysis and apply for various qualitative and quantitative assessments.	
4	Discuss methods for petrochemical analysis	
5	Apply experimental methods for soil analysis and water sample testing.	

SEMESTER-II			
CC-204	Analytical Chemistry	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Analytical Chemometrics Propagation of measurement of uncertainties, useful statistical tests: Test of significance, F- test, t-test, chi-square-test, correlation coefficient, confidence limits of mean, comparison of mean with true values. Regression analysis (least square method for linear and nonlinear plots). Statistics of sampling and detection limit evaluation. Specific study for analytical method validation by using validation parameters: (1) accuracy, (2) precision (repeatability and reproducibility), (3) linearity and range, (4) Limit of Detection (LOD) and Limit of quantification (LOQ), (5) selectivity/specificity, and (6) Robustness and Ruggedness. Problems.	14	
Unit.2	Intellectual Property Rights (IPR) Introduction, various Technical Terms, Legislation, IPA in India, Criteria for Patent, Patent for Polymorph, case studies.	10	
Unit.3	Pharmaceutical Analysis Introduction to Pharmacopeia and Pharmacopeial analysis: Physical and chemical tests: Physical verification and colour test, Loss on drying, loss on ignition, Tape and Bulk Density, Determination of moisture, limit test for heavy metals, Limit test for Halogens, Purity and assay determination by classical methods, Concept for Potency determination. Introduction of Disintegration and Dissolution tests, types of Dissolution apparatus, Types of Dissolution media, Application.	12	
Unit.4	Analysis of Petrochemical Products Petroleum: Introduction, Definition, Composition, Test methods for following: Naphtha: Aniline and Mixed Aniline point, Composition, Density, Evaporation rate, Flash point, Velocity, Volatility, Appearance, Kauri-Butanol value. Gasoline: Additives, Composition, Corrosiveness, Density, Flash and Fire point, Volatility, Water and Sediments Kerosene: Acidity, Composition, Flash and Fire point, Pour point, Density, Viscosity, Water and Sediments	12	

	Diesel: Acidity, Composition, Flash and Fire point, Pour point, Density, Viscosity, Water and Sediments Distillate Fuel oil and Mineral oil: Acidity, Composition, Flash and Fire point, Pour point, Density, Viscosity, Water and Sediments	
Unit.5	Analysis of Soil and Water Soil: Introduction, Importance of soil testing, Types of soils and analysis of soil for following: pH, Electrical Conductance, Organic Carbon, Determination of Sodium, Potassium, Boron, Phosphorous. Water: Introduction, Sampling techniques, Preservation and Pre-concentration methods, Determination of following: Total Acidity, Alkalinity, Free Carbon Dioxide, Chloride, Calcium, Magnesium, Iron, Silver, Heavy Metals, DO, COD, BOD, National and International standards for drinking water.	12
Reference Books 1. Modern Analytical Chemistry by Alka L. Gupta, Pragati Prakashan, 2nd Edition (ISBN:978-93-5140-571-9) 2. Practical Statistics (Vol 1 and 2) by Singh, Atlantic Publishers.2003. 3. V. K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions. CRC, 2008. 4. Spectroscopy 14th edition -2018 by H. Kaur, Pragati Prakashan, Meerut. Environmental Chemistry by V. K. Ahluwalia Ane Books India First Edition. 5. Environmental Chemistry by B.K. Sharma, Gole Publishing House 6. Methods for Analysis of Petroleum Products by ASTM, International USA 7. Indian Pharmacopeia, 2022, 9th Edition, Government of India, Ministry of Health and Welfare, Published by IPC, Ghaziabad.		

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CP-205	Practical	6 Credits & 12 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Perform qualitative analysis of a multifunctional organic compounds	
2	Perform synthesis of organic compounds and demonstrate its mechanism.	
3	Demonstrate and Calibration of glassware & apparatus.	
4	Prepare and standardize the solutions.	
5	Measure the % Assay and % Purity of fine chemicals.	

SEMESTER-II			
CP-205	Practical	12 hrs./Wk	6 Credits
SR. No.	Practical Detail	Lab Hours	
1	Organic Chemistry Practicals (50 Marks)	6	
	Group-A: Qualitative Analysis of Bi-functional organic compounds (Minimum 10 Compounds) (25 Marks): • Anthranilic acid • p-Aminobenzoic acid • o-Chlorobenzoic acid • m-Nitrobenzoic acid • o/m/p-Nitroaniline • Bi-phenyl amine • N, N-Dimethyl aniline • Resorcinol • Ethyl acetoacetate • P-Dichlorobenzene • o/p-Cresol • o/m/p-Toluidine • Benzanilide • Acetamide • α/β-Naphthole NOTE: Other bifunctional compounds may be asked in examination.		
	Group-B: Single Step Synthesis (25 Marks): 1. Phenyl urea from aniline 2. m-diNitro benzene aniline from nitrobenzene. 3. Hydro quinone diacetate from hydroquinone. 4. 1,2,3,4-Tetrahydrocarbazole from Cyclohexanone 5. p-Nitroacetanilide from aniline.		

	6. 7-Hydroxycoumarine from resorcinol. 7. Hippuric acid from glycine. 8. Benzilic acid from Benzil 9. Phthalamide from phthalic anhydride. 10. Resacetophenone from resorcinol.	
2	Analytical Chemistry Practicals (50 Marks) Group-A: Analytical estimation (25 Marks) 1. Preparation and Standardization of solutions. 2. Calibration of glassware and apparatus. 3. To determine the % purity of Aspirin. 4. To determine the % of Zinc Oxide by reduce titration method. 5. To determine the amount of Calcium and Zinc in given sample. 6. To determine the volume strength of H ₂ O ₂ . 7. To determine the % purity of given Phthalic anhydride. 8. To determine the % purity of given Malic anhydride. 9. Estimation of Calcium and Magnesium in given sample. 10. To determine the amount of Tin from solder wire. Group-B: Analysis of Food and Drug (25 Marks): 1. % purity of Aspirin, Paracetamol, Valproic acid, Ascorbic acid etc. 2. Total protein content in milk. 3. Peroxide value of oil sample. 4. Saponification value of oil sample. 5. Percentage of starch content in turmeric powder. 6. Amount of iodine in the given iodized salt. 7. The percentage of reducing sugars in honey sample.	6
	Reference Books 1 Brian S. Furniss (1989, Fifth edition) Vogel's Textbook of Practical Organic Chemistry. Hoboken: John Willey & Sons (ISBN: 0-582-462363). 2 Svehla, G. (1996, Seventh edition) <i>Vogel's Qualitative Inorganic Analysis</i> . New Jersey: Pearson Education. (ISBN: 0582218667). 3 Parsania P. H (2005, 1st edition) Experiments in Physical Chemistry, Granth Nirman Board 4 Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989) Vogel's Textbook of Quantitative Chemical Analysis. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).	

M.Sc. Chemistry SEMESTER-II			
CC-206	Viva Voce	-	1 Credits
Comprehensive viva voce based on practical and core courses			

SEMESTER-II		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
CP-207	Research Writing	1 Credits & 2 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand research journal, citations, impact factors and publication processes.	
2	Comprehend literature from research journals	
3	Prepare review articles using literature survey	
4	Justify research objective and methodology	

SEMESTER-II			
CC-207	Research Writing	2 hrs./Wk	1 Credits
• Various journals, data mining • Article formats, various literature search options • Recent publication, citation index • Impact factor • Review article writing preparation and submission in the given format: ▪ Title, abstract, introduction, literature survey, summary, references			

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-301	Pharma Regulatory Affairs-I	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand good laboratory practices.	
2	Discuss fundamental documentation practices in regulatory pharmaceuticals.	
3	Illustrate design, installation, operational and performance qualification of sophisticated instruments.	
4	Compare and analyze standard calibration methods for traditional and modern analytical instruments.	
5	Demonstrate experimental method and statistics for method validation.	

M.Sc. (Analytical Chemistry) SEMESTER-III			
AC-301	Pharma Regulatory Affairs- I	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Good Laboratory Practices History, Introduction, definition, principles of good laboratory practice.	12	
Unit.2	Documentation Introduction and outline of standard operating procedures (SOP), Preparation of SOP, SOP of SOPs, benefits of SOPs, guidelines for writing SOPs, example and drafting of SOPs for various departments, supporting data formats of SOPs, preparation of standard testing procedures (STP), Raw data sheets (RDS), batch manufacturing/cleaning records (BMR/BCR) and other system related documents, Review and Control of Documents.	12	
Unit.3	Qualification Introduction, basic concept and objectives of qualification, types of qualifications, qualification parameters (IQ/OQ/PQ/DQ/MQ), qualification of chemist/analyst, qualification of instrument/apparatus, facility qualification, preparation of qualification documents.	12	
Unit.4	Calibration Introduction, need of calibration, types of calibration, calibration procedures for minor and major instruments, calibration standards, calibration frequency, preventive maintenance, change control.	12	
Unit.5	Validation Analytical method validation: General principles, types of validation, validation of analytical method as per ICH guidelines and USP. Process validation: Concept, process and documentation of process validation. prospective, concurrent & retrospective validation, re-validation criteria, Concept of process validation.	12	

Reference Books

- 1 Modern Approaches to Quality Control - by Isin Akyar, Web of Science
- 2 Bentley's Pharmaceuticals.
- 3 GMP practices for pharmaceutical –James Swarbrick.
- 4 How to practice GMPs - by P.P.Sharma.
- 5 Pharmaceutical Process Validation - by Loftus and Nash.
- 6 Good Manufacturing Practices for Pharmaceuticals by Graham P. Bunn Seventh Edition, CRC Press, Taylor & Francis Group.
- 7 ICH guidelines on Harmonization.

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-302	Pharmaceutical Technology	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Justify fundamental theories of powder and its applications in pharmaceuticals.	
2	Define and relate basic theories of solution, suspension and emulsion for liquid dosage form.	
3	Express theoretical and practical aspects of tablet dosage form.	
4	Explain types, preparation and applications of capsule dosage form.	
5	Distinguish theoretical and practical aspects of pharmaceutical excipients.	

M.Sc. (Analytical Chemistry)			
SEMESTER-III			
AC-302	Pharmaceutical Technology	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Powders Introduction, Particle size, Expression of Diameter, Methods for particle characterization and Determination of Particle Size, Bulk Properties of Powder like Surface area, Porosity, Flowability, Water content, Solubility etc. Production Methods, Particle Size Reduction, Introduction of methods like SEM/TEM and Particle Size Analyzer	12	
Unit.2	Solutions, Suspensions and Emulsions Solutions: Introduction, Solvents for Liquid Pharmaceutical preparations, Preservatives, Sweet and other aqueous solutions, Non-aqueous solutions, Jellies, Elixirs etc, Commercial. Suspensions: Introduction, Physical Characteristics, Preparation of Suspensions, Sustained Release Suspensions, Commercial Preparations. Emulsions: Introduction, Types, Theory of Emulsion, Commercial Preparations.	12	
Unit.3	Solid Dosage Forms: Tablet: Definition, Advantages and Disadvantages, Types of tablets, Granulation techniques, Machinery for large scale granulation and compression, Physics of tablet making, In process controls, processing problems and remedies. Types of coating, Film forming materials, Coating process, Coating defects.	12	
Unit.4	Solid Dosage Forms: Capsules: Definitions, Advantages, disadvantages, Ideal requirements, Production of Hard capsules (Gelatine and non-gelatine eg. vegetable), Capsule storage, Size of capsules, Methods of capsule filling, Problems and Remedies, Quality control. Soft Gelatine Capsules: Formulation of shell and capsule coat, and Quality control.	12	
Unit.5	Pharmaceutical Excipients	12	

	History, Introduction, Classification of Excipients, Discussion of its role in Pharmaceutical Preparations, Examples in each case with basic properties, Some case studies and Preparation of formulation.	
Reference Books 1. The Theory and Practice of Industrial Pharmacy by L Lachman, H Lieberman and J 2. Kanig. Gennaro, Alfonso R., Remington: The Science and Practice of Pharmacy, Vol-I & II, Lippincott Williams & Wilkins, New York. 3. Pharmaceutical Dosage Forms and Drug Delivery Systems by Ansel& others. 4. Pharmaceutics: The Science of Dosage Form Design by Michael E. Aulton 5. Remington: Essentials of Pharmaceutics, by Linda A. Felton, Published by Pharmaceutical Press, London, 2013 6. Pharmaceutical Quality by Design, A Practical Approach, by Mark Gibson & Walkiria Schilndwein., Wiley Publication		

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-303	Instrumental Method of Analysis	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Define and discuss basic theory and applications of X-ray method.	
2	Illustrate fundamental techniques in fluorescence spectroscopy and its applications.	
3	Classify and relate theoretical and practical aspects of atomic emission and absorption spectroscopy.	
4	Describe theory and applications of MR Imaging techniques.	
5	Discuss the theoretical and practical aspects of flame photometry.	

M.Sc. (Analytical Chemistry)				
SEMESTER-III				
AC-303		Instrumental Method of Analysis	4 hrs./Wk	4 Credits
SR No.	Course Detail			Inst. Hrs.
Unit.1	X-ray Method Introduction, generation of X-rays, X-ray diffraction, Bragg’s law, X-ray powder diffraction, X-ray single crystal diffraction interpretation of diffraction pattern, applications of XRD and numerical.			12
Unit.2	Fluorescence Spectroscopy Introduction, principle, types of fluorescence mechanism, types of chemosensors (e.g. Rhodamine and coumarin based chemosensors), instrumentation, advantages and disadvantages, applications in chemistry, biology, agrochemicals and water.			12
Unit.3	Atomic Absorption and Emission Spectroscopy Atomic absorption spectroscopy (AAS): principle, classification of atomic spectroscopic method, measurement of atomic absorption, instrumentation, sensitivity, detection limits, application, advantages, and disadvantages Atomic Emission spectroscopy (AES): Introduction, principle, theory of emission, instrumentation, applications, advantages and disadvantages			12
Unit.4	MR Imaging Technique Magnetic resonance imaging (MRI) - principle, instrumentation, magnetic resonance angiography, ¹ H NMR of relevant diamagnetic and paramagnetic compounds, contrast agents and clinical applications.			12
Unit.5	Flame Photometry Introduction, principle, instrumentation, types of flame photometers, limitations of flame photometry, applications.			12
Reference Books				
1. Fundamentals of Analytical Chemistry – Skoog, Harcourt College Publishers.				
2. Quantitative chemical analysis – Vogel A. I., Pearson Education.				
3. Text Book of Pharmaceutical Analysis – K. A. Connor, John Willey & Sons, New York.				
4. Quantitative Chemical Analysis – Ayer by Harper & Row, New York.				

5. Instrumental Methods of Analysis by B. K. Sharma, Goel Publisher, Meerut
6. Modern Analytical Chemistry – by Alka L. Gupta, Pragati Prakashan.
7. Instrumental methods of chemical analysis – by H. Kaur, Pragati Prakashan.
8. Instrumental methods of analysis – by B. Sivasankar, Oxford University Press.
9. Principles of Fluorescence Spectroscopy by Joseph R. Lokowicz, University of Maryland, Baltimor, USA, Springer Publication. (ISBN: 10;0-387-31278-1) (EISBN: 13;978-0-387-46312-4)

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-304	Modern Spectroscopy	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand Principle and theory of various spectroscopy. i.e. UV-Vis, FT-IR, NMR Spectroscopy and Mass Spectrometry.	
2	Discuss Instrumentation of UV-Vis, FT-IR, NMR Spectroscopy and Mass Spectrometry.	
3	Demonstrate competence in collecting and interpreting data in the laboratory.	
4	Solve problems related to the saturation, functional group, molecular weight and structure of molecules	
5	Analyze and interpret spectroscopic data for structure elucidation.	

M.Sc. (Organic Chemistry) SEMESTER-III			
AC-304	Modern Spectroscopy	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs.	
Unit.1	Introduction to spectroscopic techniques Types of analytical techniques, introduction of instrumental methods and its classification, overview of spectroscopic methods based on wave length regions of electromagnetic radiation, properties of electromagnetic radiation. UV Spectroscopy Introduction, theory of ultra violet spectra, instrumentation, type of transition in organic molecules; auxochrome, chromophore; explanation of bathochromic shift and hypsochromic shift, hyper chromic effects, types of bands, effect of solvent, application of UV spectra. Calculation of λ -max (1) dienes and conjugated dienes (2) enones and dienones (ie. unsaturated carbonyl compounds) (3) aromatic carbonyl system.	10	
Unit.2	Infrared Spectroscopy: Introduction to IR and FTIR, principle & theory of Infrared absorption spectrometry, infrared sources and transducers, sample handling, instrumentation, interpretation of IR spectra, applications and limitations of IR spectroscopy.	08	
Unit.3	Mass Spectroscopy Introduction, principle, theory and components of mass spectrometers, different ionization and detection techniques, recording and resolution of mass spectrometer, types of ions produced in mass spectrometer, interpretation of mass spectra of selected compounds /API, Applications of Mass spectrometry, Introduction to ICP-MS.	08	
Unit.4	Nuclear Magnetic Resonance Spectroscopy-I Introduction, NMR active nuclei, Basic Theory, NMR Spectrometer, internal Standard & solvent.	14	

	¹H NMR (PMR): Principle, Chemical shift, Magnetic anisotropy, spin-spin coupling (multiplicity), applications & problems of Nuclear magnetic resonance spectroscopy.	
Unit.5	Nuclear Magnetic Resonance Spectroscopy-II ¹³ C NMR: Introduction, Principle, chemical shift, application and problems of ¹³ C – NMR. Introduction to 2D NMR, Application of COSY, NOESY, HSQC, HMBC Structure Elucidation: Structure determination and distinction of various isomeric compounds through spectroscopic techniques (UV, IR, Mass, NMR & 2D-NMR)	20
Reference Books 1. Martin, M. L., Delpuech, J. J. and Martin, G. J. (1980) Martin *Practical* Nmr Spectroscopy. Weinheim: John Wiley & Sons Ltd. (ISBN: 0471258652). 2. Silverstein, Robert M., Webster, Francis X., Kiemle, David J., Bryce, David L. (2014, Eighth edition) Spectrometric identification of Organic Compounds. Weinheim: John Wiley & Sons Ltd. (ISBN: 978-0-470-91401-4). 3. Abraham, R. J., Fisher, J. and Loftus, P. (1988) Introduction to NMR Spectroscopy. Weinheim: John Wiley & Sons Ltd. (ISBN: 0471918946). 4. Dyer, J. R. (1965) Application of absorption Spectroscopy of Organic Compounds. Upper Saddle River: Prentice Hall. 5. Williams, D. H., Fleming, I. (2007, Sixth edition) Spectroscopic Methods in Organic Chemistry. New Delhi: Tata McGraw-Hill. (ISBN: 007711812X). 6. Kalsi, P. S. (2006, Sixth edition) Spectroscopy of Organic Compounds. New Delhi: New Age International Pvt. Ltd. (ISBN: 8122415431). 7. Breitmaier E. (2002, Third edition) Structure elucidation by NMR in Organic Chemistry-A Practical approach. Weinheim: John Wiley & Sons Ltd. (ISBN: 978-0-470-85007-7). 8. Elementary Organic Spectroscopy (2013) by Y. R. Sharma, S. Chand and Company Pvt. Ltd. (ISBN: 81-219-2884-2)		

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-305	Practical	6 Credits & 12 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Prepare and analyze pharmaceutical preparations.	
2	To perform tablet/capsule testing and evaluate various parameters.	
3	Apply UV Viz. phenomena to find out wavelength, concentration and chemical shifts of organic molecules.	
4	Interpret IR spectrum for identification of various functional group in organic molecules.	
5	Operate flame, polarimeter, UV-Visible and IR spectrophotometer.	

M.Sc. (Analytical Chemistry)			
SEMESTER-III			
AP-305	Practical & Viva	12 hrs./Wk	6 Credits
SR. No.	Practical Detail	Lab Hours	
	Group A: Preparation and Estimations (50 Marks): 1. Preparation and evaluation of simple syrup IP. 2. Preparation and evaluation of suspension (e.g., milk of magnesia) 3. Preparation and evaluation of eye drop (e.g., atropine sulphate) 4. Preparation and evaluation of infusion (e.g., 5% dextrose, metronidazole) 5. Preparation and evaluation of injection (e.g., ascorbic acid IP, NaCl IP) 6. Preparation and evaluation of lotion (e.g., calamine IP) 7. Determination of tablet weight variation (IP/EP/USP). 8. Determination of capsule weight variation (IP/EP/USP). 9. Determine content uniformity of given tablets (traditional/instrumental). 10. Determination of friability and hardness of given tablet sample (IP/EP/USP). Group B: Instrumentation analysis (50 Marks): 1. Determination of λ max of given samples by visible spectrophotometer. 2. Determination of λ max of given samples by UV-Vis spectrophotometer. 3. Evaluation of effect of solvents on given sample and to identify the type of shift by UV-Vis spectrophotometer. 4. Control of absorbance and limit of stray light on UV-Vis spectrophotometer. 5. Calibration of polarimeter. 6. Specific rotation determination by polarimeter. 7. Estimation of metal from various water samples by flame photometer. 8. Estimation of metals from various drug samples by flame photometer.	12	

	9. Estimation of metals from various soil samples by flame photometer. 10. Determination of bleachability index (DOBI) of palm oil by UV-Vis spectrophotometer. 11. Demonstrative practicals of IR and fluorescence spectroscopy.	
Reference Books 1. Brian S. Furniss (1989, Fifth edition) Vogel's Textbook of Practical Organic Chemistry. Hoboken: John Willey & Sons (ISBN: 0-582-462363). 2. Arthur I. Vogel. (Second edition) Elementary practical organic chemistry: small scale preparations. Pearson (ISBN: 978-81-317-5686-7). 3. Svehla, G. (1996, Seventh edition) Vogel's Qualitative Inorganic Analysis. New Jersey: Pearson Education (ISBN: 0582218667) 4. Remington: Essentials of Pharmaceutics, by Linda A. Felton, Published by Pharmaceutical Press, London, 2013. 5. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989) Vogel's Textbook of Quantitative Chemical Analysis. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).		

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AP-306	Research Project Proposal & Viva Voce	2 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Analyze published literature	
2	Perform critical analysis of literature survey and established research scope	
3	Create research aims and objective	
4	Identify appropriate research methodology to full fill research objective	
5	Create research proposal in the prescribed format	

M.Sc. (Analytical Chemistry) SEMESTER-III			
AP-306	Research Project Proposal & Viva Voce	4 hrs./Wk	2 Credits
Research proposal Writing Guideline (Minimum 5000 words): 1 Explanation of various research funding agencies (UGC, DBT, DST, CSIR, SERB, GUJCOST) & their research support schemes. 2 Training on how to write various aspects of research proposal in given format with one example (Title, description of problem, review of related work, national & international status, rationale for taking up project, objective of proposal, methodology, references, year-wise work plan, budget estimation etc.) 3 Assign chemistry-based research problems and its literature review. 4 Preparation and submission of one research proposal for any one funding agency 5 Presentation (ppt) of the prepared research proposal including all aspects at the time of external exam. 6 Viva voce will be based on the research proposal and its various aspects.			

SEMESTER-III		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-401	Pharma Regulatory Affairs-II	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Explain current regulatory requirements for Organization, Personal, Premises, Equipment and Raw materials to maintain GMP.	
2	Discuss current regulatory requirements for Manufacturing and control, In-process quality control, Packaging and labelling control and Quality control to maintain GMP.	
3	Illustrate current regulatory requirements for Finish product, Warehousing, Distribution and distribution records, Handling of returned goods, recovered materials and reprocessing, Complaints and recalls to maintain GMP.	
4	Apply theory, its execution and applications of stability studies in pharma industries.	
5	Understand and recognize the importance of regulatory documentation.	

M.Sc. (Analytical Chemistry)			
SEMESTER-IV			
AP-401	Pharma Regulatory Affairs-II	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs	
Unit.1	Good Manufacturing Practices Organization: Structure, Chart, And Role, Personnel: Responsibilities, Training, and Hygiene. Premises: Location, Design, Plant Layout, Construction, Maintenance and Sanitation, Environmental control, Equipments: Selection, Specifications, SOPs, Qualifications, Maintenance, Clean in place, Sterilize in place. Raw Materials: Specifications, Storage, Selection of Vendors, Vendor qualification, Control on Raw materials and Finished products	12	
Unit.2	Good Manufacturing Practices Manufacturing & control: Manufacturing documents, Batch formula records, SOPs, Quality audits of manufacturing processes and facilities, In-Process quality controls: Role of IPQC, In process testing, SOP for various operations like cleaning, filling, drying, compression, coating, disinfections, sterilization. Packaging and labelling control: Reconciliation of labels, cartons and other packaging materials, Quality control Laboratory: Responsibilities, Routine controls instruments, Reagents, Sampling plans, SOPs, STPs, Protocols, Data generation and storage, quality control documents, Retention samples, Records, Audits of quality control facilities	12	
Unit.3	Good Manufacturing Practices Finished product: Product release, Quality review, Quality audits and batch release documents, Warehousing: Design, Construction, Maintenance and Sanitation, Distribution and distribution records, Handling of returned goods, recovered materials and reprocessing, Complaints and recalls: Evaluation of complaints and related records. Example and case studies for violation of GMP practices	12	
Unit.4	Stability Studies	12	

	Introduction and objectives of stability study, Importance, Order of reaction and their applications in predicting shelf life and half-life. climates zones and conditions, sampling, packing and storage conditions. Effect of various environmental/ processing factors like light, pH, temperature, etc. Introduction to chemical stability of drugs, pathways for chemical degradations: hydrolysis, dehydration, oxidation, photodegradation	
Unit.5	Regulatory Documentation Introduction, Elements and Preparation Site Master File (SMF). Introduction, Background, Elements and types of Drug Master File (DMF), Filling of DMF, Regulatory requirements, Introduction of various international regulatory agencies like USFDA, PMDA, TGA, MHRA and CDSCO. Objectives, role and functioning of CDSCO and USFDA.	12
Reference Books 1. GMP practices for pharmaceutical –James Swarbrick. 2. How to practice GMPs - by P. P. Sharma. 3. ICH guidelines on Harmonization. 4. Good Manufacturing Practices for Pharmaceuticals by Graham P. Bunn Seventh Edition, CRC Press, Taylor & Francis Group. 5. Drug stability -Principles and Practices - by Jens. T. Carstensen. 6. Stability of drug and dosage forms - by S. Yoskioka, and V. J. Stella, Springer. (ISBN: 978-81-8128-239-6)		

SEMESTER-IV		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-402	Separation Techniques	4 Credits & 4 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Understand the principle, fundamental theory and instrumentation of various planar and column chromatographic techniques.	
2	Identify the significance, quality, and limitations of the results produced by the various separation techniques.	
3	Apply theoretical knowledge to design and develop suitable extraction techniques for separation and identification of organic/natural compounds.	
4	Calculate R _f values and Interpret HPLC and GC chromatograms to perform qualitative analysis of unknown.	
5	Differentiate various applications of separation techniques to medicinal and pharmaceutical field.	

M.Sc. (Analytical Chemistry) SEMESTER-IV			
AC-402	Separation Techniques	4 hrs./Wk	4 Credits
SR No.	Course Detail	Inst. Hrs	
Unit.1	Adsorption and Partition Chromatography History, introduction, classification, principles, experimental, factors affecting adsorption & partition chromatography	12	
Unit.2	Planar Chromatography Principle, basic theory, technique & applications of: Paper chromatography, thin layer chromatography and high-performance thin layer chromatography	12	
Unit.3	Gas Chromatography Basic theory, instrumentation, working and applications of GC & HS-GC	12	
Unit.4	Liquid Chromatography Basic theory, instrumentation, working and applications of HPLC & LC-MS	12	
Unit.5	Extraction Techniques Introduction, types of extraction (LLE, SSE, LSE), extraction methods (maceration, infusion, digestion, decoction, percolation, solvent extraction, soxhlet extraction, counter current extraction, sonication, supercritical fluid extraction, steam distillation) and application.	12	

Reference Books

1. Sethi, P. D. (2013) Sethi HPTLC: High Performance Thin Layer Chromatography: Quantitative Analysis of Pharmaceutical Formulations 3 Volume Set. New Delhi: CBS Publishers & Distributors Pvt. Ltd. (ISBN: 9788123922799).
2. Stahl, E. (1969, Second edition) Thin Layer Chromatography: A Laboratory Handbook. New Berlin: Springer. (ISBN: 978-3-642-88488-7).
3. Heftmann, E. (2004, Sixth edition) Fundamentals and applications of chromatography and related differential migration methods - Part A (Journal of Chromatography Library). Philadelphia: Elsevier Publishing Company. (ISBN: 0444511075).
4. Skoog, D. A., West D. M., Holler, F. J., Crouch, Stanley R. (2013, Ninth edition) Fundamentals of Analytical Chemistry. Boston: Cengage Learning. (ISBN: 0495558281)
5. Instrumental Methods of Analysis by B. K. Sharma, Goel Publisher, Meerut.

SEMESTER-IV		
Paper No.	Course (Paper) Title	Course credit & teaching hrs
AC-403	Dissertation/Project or Practical	12 Credits & 24 hrs./Wk
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Apply critical and analytical skills in a scientific and professional manner.	
2	Plan and develop research project with critically apprising and interpretative published literature	
3	Synthesize knowledge and skills previously gained and applied to an in-depth study.	
4	Compare and select from different research methodologies, methods and forms of analysis to produce a suitable research method.	
5	Present the finding of their project in a written report.	
Practical		
Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	CO Statement	
1	Demonstrate analytical laboratory setup.	
2	Apply understanding of various instrumentation methods and regulatory documentation to perform method validation parameters.	
3	Analyze product formation by using physical measurement, separation and purification techniques.	
4	Design and develop solvent system for separation/extraction and identification of organic/natural compounds from single/multi-step reactions.	
5	Construct manual thin layer chromatography and column chromatography whenever applicable.	

M.Sc. (Analytical Chemistry) SEMESTER-IV			
AP-403	Dissertation/Project or Practical	24 hrs./Wk	12 Credits
- All the students of M.Sc. Analytical Chemistry will have option to undertake a research dissertation/project or practical during semester- IV. - The student shall pursue his/her dissertation work under <u>university recognized research guide</u> only. Dissertation/Project Detail (200 Marks): - The student will be given the option of selecting a research problem in a preferred area that falls within the discipline of courses undertaken. - The dissertation/project work could be conducted at the institute or recognized research laboratory. In case the student carries out research work at other research laboratory, a NOC, presence report and certificate of place of work from the concern laboratory should be submitted along with the thesis. - At the end of the semester, the student is required to submit his/her results in the form of a dissertation thesis. A student must submit 3 copies of his/her dissertation at the time of			

evaluation duly signed by candidate, guide and head of the institution. The thesis should include plagiarism certificate duly signed by candidate, guide and head of the institution.

- The format of the Dissertation/project thesis should be as under:
 - (a) The thesis should be typewritten on A4 size paper printed on both side in Times New Roman font with 12 size.
 - (b) A margin of at least 1.5 cm must be left at the left side of each page and a margin of 1.0 cm on the top, bottom, and right side of each page.
 - (c) The dissertation thesis shall arrange in the following sequence: Title, introduction of research problem, aims and objectives of the research undertaken, result and discussion, experimental section with characterization of compounds including spectral analysis, conclusion, and latest references as per the Scopus index research journal format.
- The evaluation (Thesis & Viva) of the dissertation/project work will be carried out during university practical examination by external examiner.

OR

Practical Details (200 Marks):

Group A: Instrumental Analysis (100 Marks):

1. Determination of wavelength for various APIs (Minimum 3 exercises).
2. Estimation of drugs (NSAID, Antacids, hypertensive, etc.) by colorimeter (Minimum 3 exercises).
3. To determine Linearity study for various APIs, Intermediates or relevant samples by UV-Vis Spectroscopy (Minimum 3 exercises).
4. To perform Accuracy study for various APIs, Intermediates or relevant samples by UV-Vis Spectroscopy (Minimum 3 exercises).
5. To perform Precision study for various APIs, Intermediates or relevant samples by UV-Vis Spectroscopy (Minimum 3 exercises).
6. To identify limit of detection and limit of quantification for given APIs samples.
7. To determine unknown concentration of drug sample by visible spectrophotometer.
8. To determine unknown concentration of drug sample by UV-Vis spectroscopy.

Group B: Separation Chemistry (100 Marks):

1. Organic mixture separation by column chromatography (Minimum 3).
2. Inorganic mixture separation by column chromatography (Minimum 3).
3. Organic mixture separation and determination of R_f value by TLC (Minimum 3).
4. Inorganic mixture separation and determination of R_f value by TLC (Minimum 3).
5. Extraction of Eugenol from clove
6. Extraction of Caffeine from Tea
7. Extraction of Cinnamaldehyde from Cinnamon
8. Extraction of Nicotine from Tobacco
9. Extraction of Curcumin from Turmeric powder
10. Extraction of Carotenoids from Tomato

Reference book

1. ICH Guidelines (Q2A) on Validation of Analytical Method.
2. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989) Vogel's Textbook of Quantitative Chemical Analysis. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).
3. Thin-Layer Chromatography by Egon stahl, Springer.

M.Sc. (Analytical Chemistry) SEMESTER-IV			
AP-404	Dissertation /Project Viva Voce or Practical Viva Voce	-	2 Credits
- Dissertation/project viva voce will be carried out in the form of a presentation of his/her dissertation thesis. The presentation should include brief introduction, objective of research, scheme of research problem, result & discussion, spectra of compounds and conclusion of the present study. OR - Comprehensive viva voce based on practical and core courses.			

Bhakta Kavi Narsinh Mehta University Junagadh

M.Sc. Chemistry

Question Paper Pattern

(Effective from June 2023)

Unit-1 [14 marks]

Answer ALL questions

Q.1 (a)	1 Question of 4 Marks OR 2 Questions of 2 Marks Each.	4 Marks
Q.1 (b)	Answer any two question out of three.	10 Marks
(1)		5
(2)		5
(3)		5

Unit-2 [14 marks]

Answer ALL questions

Q.2 (a)	1 Question of 4 Marks OR 2 Questions of 2 Marks Each.	4 Marks
Q.2 (b)	Answer any two question out of three.	10 Marks
(1)		5
(2)		5
(3)		5

Unit-3 [14 marks]

Answer ALL questions

Q.3 (a)	1Question of 4 Marks OR 2 Questions of 2 Marks Each.	4 Marks
Q.3 (b)	Answer any two question out of three.	10 Marks
(1)		5
(2)		5
(3)		5

Unit-4 [14 marks]

Answer ALL questions

Q.4 (a)	1 Question of 4 Marks OR 2 Questions of 2 Marks Each.	4 Marks
Q.4 (b)	Answer any two question out of three.	10 Marks
(1)		5
(2)		5
(3)		5

Unit-5 [14 marks]

Answer **ALL** questions

Q.5 (a)	1 Question of 4 Marks OR 2 Questions of 2 Marks Each.	4 Marks
Q.5 (b)	Answer any two question out of three.	10 Marks
(1)		5
(2)		5
(3)		5
