UNIVERSITY OF GOUR BANGA, MALDA

CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES IN CHEMISTRY

Draft Course Structure

for the 4-Year Under Graduate (B.Sc. Chemistry) Programme under NEP, 2020

Semester(I – VIII)	Major Course (MC)/DSC 92 Credits (23 Papers x 4 credits)	Minor Core (MnC) 32 Credits (8 papers x 4 credits)	Multi-Disciplinary/ Interdisciplinary (IDC)/(MDC) 9 Credits (3 papers x 3 credits)	Ability Enhancement Course (AEC)** 8 Credits (4 papers x 2 credits)	Skill Enhancement Course (SEC) 12 Credits (4 papers x 3 credits)	Value Addition course (VAC)** 6 Credits (3 papers x 2 credits)	Intern-ship 2 Credits	Dissertation / Project 12 Credits (3 papers x 4 credits)	Total Credit (173 Credits)
I	2x4 =8 MC 1 MC 2	1x4=4 MnC 1	1x3=3	1x2=2 (MIL-1)	1x3=3	1 x2 =2 (ENV S)			22
II	2x4 =8 MC 3 MC 4	1x4=4 MnC 2	1x3=3	1x2=2 (MIL-2)	1x3=3	1 x 2 =2	2 #		22 + 2 #
Student on exit shall be awarded Under Graduate Certificate in Chemistry after securing the requisite 44 Credits in Semesters I and II in addition to completion of Internship of 2 credits (optional) [# = optional]									
III	2x4=8 MC-5, MC-6	1x4=4 MnC 3	1x3=3	1x2=2 (Eng 1)	1x3=3				20
IV	3x4=12 MC-7, MC-8, MC-9	1x4=4 MnC 4		1 x2=2 (Eng 2)			2#		18 + 2#
Student on exit shall be awarded Under Graduate Diploma in Chemistry after securing the requisite 84 Credits in SemestersI II, III and IV along with completion of Internship of 2 credits									
V	4x4=16 MC-10, MC-11, DSC-1, DSC-2	1x4=4 MnC 5				1 x 2 =2			22
VI	4x4=16 MC-12, MC-13, DSE-3, DSE-4	1x4=4 MnC 6							20
Student on exit shall be awarded Bachelor Degree in Chemistry (B.Sc) after securing the requisite 128 Credits in Semesters I to VI									
VII	3x4=12 MC-14, DSE-5, DSE-6	1x4=4 MnC 7						1x6=6 Dissertation Major or Project)	22
VIII	3x4=12 MC-15, DSE-7, DSE-8	1x4=4 MnC 8						1x6=6 Dissertation Major or Project)	22
Total credits	23 x 4 =92	8 x 4 = 32	3 x 3 = 9	4 x 2 = 8	3 x 3 = 9	3 x 2 = 6	2 #	6 x 2 = 12	170
Marks	23 x 50 = 1150	8 x 50 = 400	3 x 50 = 150	4 x 25 = 100	3 x 50 = 150	3 x 25 = 75	1 x 25 = 25	75 x 2 = 150	2200
Student on exit shall be awarded Bachelor Degree in Chemistry with Research [B.Sc (Honours with Research in Chemistry)] after securing the requisite 170 Credits in Semesters I to VIII along with completion of Internship									

4 credit / 3 credit = 50 Marks and 2 credit = 25

UNIVERSITY OF GOUR BANGA, MALDA

Four Year B.Sc. (Chemistry) Programme as per National EducationPolicy (NEP), 2020

Year	Semester	Course	Title of the Course	Credits
First year	Sem - I	MC-1	Organic Chemistry I	4
		MC-2	Physical Chemistry I	4
		MnC-1	Inorganic Chemistry I + Organic Chemistry I	4
		(IDC) /MDC-1		3
		AEC-1		2
		SEC-1	Basic Analytical Chemistry	3
		VAC-1		2
		Total Credit for I Semester		22
	Sem - II	MC-3		4
		MC-4		4
		MinC-2		4
		(IDC) /MDC-II		3
		AEC-2		2
		SEC-2		3
		VAC-2		2
		Internship		2 #
		Total Credit for II Semester		20 +2 #
		Total Credit for First Year (Semester I & II)		42 + 2 #
Second year	Sem- III	MC-5		4
		MC-6		4
		MnC-3		4
		(IDC) /MDC-III		3
		AEC-3		2
		SEC-3		3
		Total Credit for III Semester		20
	Sem-IV	MC-7		4
		MC-8		4
		MC - 9		4
		MnC-4		4
		AEC-4		2
		Internship		2
		VAC-2		2 #
		Total Credit for IV Semester		18 + 2 #
		Total Credit for First & Second Year		82

Semester – I
Organic Chemistry I

MC-1 (Theory) **(Credit: 03)**

Total Lectures: 45

1. Bonding and Physical Properties: (15L)

VBT: A Fundamental Approach
Concept of hybridization – shapes of molecules, Orbital Pictures of Bonding, Bond Polarization and Bond Polarizability, Resonance and Hyperconjugation, DBE and Formal Charge Mesomeric Effect and Resonance Energy Electromeric Effect, Steric Effect – concepts and applications.

Molecular Orbitals: A Fundamental Approach
Bonding and Antibonding Interactions, Types of Molecular Orbitals: σ, σ^*, π, π^*, n. Overview of Frontier MOs (FMO) - HOMO, LUMO and SOMO. Chemical Reactivity in terms of FMO Interactions – Basic Applications. Hückel's Rules for Aromaticity. Concepts of Antiaromaticity and Homoaromaticity. Frost Diagram.

Fundamental Physical Properties of Organic Molecules:
Significance of bond dissociation energy (BDE) and bond energy Impact of hybridization on BDE, bond energy, bond distances and angles. Understanding the role of bond angle strain in organic compounds Impact of covalent and non-covalent intermolecular forces on melting point, boiling point, and solubility. Relative Stabilities of Isomeric Hydrocarbons heat of hydrogenation, heat of combustion, and heat of formation.

2. Reaction Mechanism: Fundamental Aspects (15L)

Mechanistic Classification of Reactions (Definition and Examples): Ionic, Radical and Pericyclic. Types of Reactions (Definition and Examples): Addition, Elimination, Substitution, Rearrangement, oxidation-reduction, tautomerization, Condensation, Polymerization. Homolytic and Heterolytic Bond Fission, Homogenic and Heterogenic Bond Formation, Types of Reagents. Reactive Intermediates (Generation, Stability, Electrophilic/Nucleophilic Behavior) and Structure): Carbocations, Carbanions, Carbon Radicals, Carbenes, Carbenoids, Benzynes and Nitrenes

3. Basic Stereochemistry (15L)

Chirality & Representation of Molecules
Concept of Chirality -Symmetry elements and point groups (C_v,D_h,C_{nh}, C_{nv}, C_n, D_{nh}, D_{nd}, D_n, S_n (C_s, Ci); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers. Fischer, sawhorse, flying-wedge and Newman projection formulae and their inter translations.

Relative and absolute configuration:
D/L and R/S descriptors; erythro/threo and meso nomenclature of compounds; syn/anti nomenclatures for aldols; E/Z descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of R/S- and E/Z- isomerisms.

Optical activity of Chiral Compounds:
Optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); optical purity and enantiomeric excess.

Reference Books:
1.Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012. 2. Smith, J. G. Organic Chemistry, Tata McGraw- Hill Publishing Company Limited. 3. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited. 4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education). 6. Fleming, I. Molecular Orbitals and Organic Chemical Reactions, Reference/Student Edition, Wiley, 2009. 7. Eames, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003. 8. Robinson, M. J., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.

MC-1/DSC-1 (Practical) **(Credit: 01)**
(30 hours)

1. Determination of boiling point:
Determination of boiling point of common organic liquid compounds e.g., ethanol, cyclohexane, chloroform, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide, etc. [Boiling point of the chosen organic compounds should preferably be less than 160 °C]

2. Identification of a Pure Organic Compound by chemical test(s):
Solid compounds:
oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid.
Liquid Compounds:
formic acid, acetic acid, methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.

Semester – I
Physical Chemistry-I

MC-2 (Theory) **(Credit: 03)**

Total Lectures: 45

1. Kinetic Theory and Gaseous State: (15L)

Kinetic Theory of Gases:
Concept of pressure and temperature; Collision diameter; Collision number and mean free path; Frequency of binary collisions. Maxwell's Distribution of Speeds in One, Two and Three Dimensions; Kinetic Energy Distribution on One, Two and Three Dimensions, Average, Root Mean Square and Most Probable velocities. Principle of Equipartition of Energy.

Gaseous State:
Deviation of Gases from Ideal Behavior; Compressibility Factor; Boyle Temperature; Andrew's and Amagat's Plots; Van Der Waals Equation and Its Features; Its Derivation and Application in Explaining Real Gas Behaviour, Critical State, Critical Constants in Terms of Van Der Waals Constants; Law of Corresponding States.

2. Thermodynamics-I: (12L)

First Law and Zeroth of Thermodynamics:
Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; First law of thermodynamics; calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence.

Thermochemistry:
Heats of reaction; enthalpy of formation; Laws of thermochemistry; bond energy, bond dissociation energy, Kirchhoff's equations and effect of pressure on enthalpy of reactions. Adiabatic Flame Temperature, Explosion Temperature

3. Kinetics: (18L)

Rate Law, Order and Molecularity:
Elementary and Non-Elementary Reactions, Rate law Rate constants, Order; Molecularity, First, second and nth order reactions; Pseudo first order reactions Determination of order of a reaction Opposing reactions, consecutive reactions and parallel reactions

Role of Temperature and Theories of Reaction Rate:
Temperature Dependence of Rate Constant; Arrhenius Equation, Energy of Activation; Steady-State Approximation; Theories of Reaction Rate: Collision Theory; Lindemann Theory of Unimolecular Reaction; Transition State Theory (Classical Treatment).

Homogeneous Catalysis:
Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation,

Reference Books:

1.Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press. 2. Castellan, G. W. Physical Chemistry, Narosa.3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.4. Engel, T. & Reid, P. Physical Chemistry, Pearson. 5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill. 6. Maron,S. & Prutton Physical Chemistry. 7. Ball, D. W. Physical Chemistry, Thomson Press. 8. Mortimer, R. G. Physical Chemistry, Elsevier. 9. Laidler, K. J. Chemical Kinetics, Pearson. 10. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry. 11. Rakshit, P.C., Physical Chemistry Sarat Book House. 12. Zemansky, M. W. & Dittman, R.H. Heat and Thermodynamics, Tata-McGraw-Hill. 13. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas. 14. Clauze & Rosenberg, Chemical Thermodynamics.

MC-2 (Practical) **(Credit: 01)**
(30 hours)

1. Determination of pH of unknown solution (buffer), by colour matching method.
2. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate.
3. Study of kinetics of decomposition of H_2O_2
4. Determination of heat of neutralization of a strong acid by a strong base.

Semester – I

Inorganic Chemistry – I & Organic Chemistry – I

MnC-1 **(Credit: 03)**

Total Lectures: 45

Inorganic Chemistry – I

1. Atomic Structure **(7L)**

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations.

2. Chemical Periodicity **(7L)**

Classification of elements on the basis of electronic configuration: general characteristics of s-,p-, d- and f-block elements. Positions of hydrogen and noble gases in the periodic table. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group- wise variation of above properties in respect of s- and p- block elements.

3. Acids and Bases **(5L)**

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.

4. Redox Reactions **(3L)**

Balancing of equations by oxidation number and ion-electron method, Standard electrode potential, formal potential, redox indicator and redox titrations.

Organic Chemistry – I

1. Fundamentals of Organic Chemistry **(3L)**

Electronic displacements: Inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals.

2. Stereochemistry **(5L)**

Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, meso compounds; threo and erythro, D and L, cis and trans nomenclature; CIP Rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclature.

3. Nucleophilic Substitution and Elimination Reactions **(6L)**

Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs substitution.

4. Aliphatic Hydrocarbons **(9L)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

Alkanes (up to 5 Carbons).

Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenations.

Alkenes: (up to 5 Carbons)

Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alkaline KMnO4) and trans-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes: (up to 5 Carbons).

Preparation: acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alkaline KMnO4.

Reference Books

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991. 2. Cotton, F.A., Wilkinson, G. &Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley. 3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons. 4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education Ind 5. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher. 6. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons.

7. Madan, R. L. Organic Chemistry, S. Chand & Sons. 8. Wade, L. G., Singh, M. S., Organic Chemistry. 9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 10. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 11. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994. 12. Sen Gupta, Subrata. Basic Stereochemistry of Organic molecules. 13. Kalsi, P. S. Stereochemistry Conformation and Mechanism, Eighth edition, New Age International, 2014. 14. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry,
S. Chand, 2010.

Practical

Inorganic Chemistry – I

MnC-1 **(Credit: 01)**
(30 hours)

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Semester – I

Basic Analytical Chemistry

(Credit: 03)

SEC-1

Total Lectures: 45

1. Introduction **(3L)**

Strategies of Analytical Chemistry and its interdisciplinary applicability. Protocol of sampling. Variability and validity of analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

2. Complexometry **(5L)**

Complexometric titrations, Chelation, Chelating agents, use of indicators. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Soil Analysis

Composition, pH of soil samples, estimation of calcium and magnesium content.

3. Analysis of water **(6L)**

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample. Determination of Biological Oxygen Demand (BOD).

4. Analysis of food products **(6L)**

Nutritional value of foods, idea about food processing and food preservations and adulteration. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of preservatives and colouring matter.

5. Chromatography **(6L)**

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}). To compare paint samples by TLC method.

6. Ion-exchange **(6L)**

Column, ion-exchange chromatography etc. 2. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

7. Analysis of cosmetics **(6L)**

Major and minor constituents and their function
Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration

8. Suggested Applications (Any one) **(3L)**

To study the use of phenolphthalein in trap cases. To analyse arson accelerants. To carry out analysis of gasoline.

9. Suggested Instrumental demonstrations **(4L)**

Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
Spectrophotometric determination of Iron in Vitamin / Dietary Tablets. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink

Reference Books

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988. 2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007. 3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994). 4. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016. 5. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004. 6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992. 7. Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982). 8. Cooper, T.G. The Tools of Biochemistry, JohnWiley & Sons, N.Y. USA. 16 (1977). 9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996. 10. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009. 11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995). 12. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.