

Chemistry Even Semester Syllabus to be implemented (After 20-09-2025; 22nd BoS) from Dec 2025

TY B.Sc. Sem-VI

St. Xavier's College (Autonomous), Ahmedabad-09



Proposed Syllabus under NEP system for Semester VI

B Sc Chemistry

(2025-2028)

November 23, 2025

Programme Specific Outcome

A student completing this program will be able to

PSO1: Knowledge: Apply the principles of inorganic and physical chemistry to solve basic chemical problems locally and globally

PSO2: Laboratory skills: Employ classical and modern laboratory techniques in the performance and documentation of experiments, suitable for a chemical industry or a chemistry graduate program.

PSO3: Environmental concern: Practice environmentally benign chemistry

PSO4: Employability/future prospects: Develop problem-solving skills and aptitude that are highly valuable to employers and entrepreneurship skills for self-employment

PSO5: Scientific communication: Have effective written and oral scientific communication skills, especially the ability to transmit complex technical information in a clear and concise manner

Table of Courses

Course Code	Course Name
CHMC661C	Inorganic Chemistry-II
CHMC662C	Analytical Chemistry-II
CHMC633L	Chemistry lab experiments -VI
CHMN661C	Nano and Material Science

St. Xavier's College (Autonomous), Ahmedabad

**Syllabus of Semester – VI of the following departments under Faculty of Science
based on Under Graduate Curriculum Framework - 2023 to be implemented
from the Academic Year 2025-26.**

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

**BSc. (Hons.) Chemistry
Category – VI**

Major Course- Inorganic Chemistry-II (Theory)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Perquisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
CHMC661C Inorganic chemistry-II	4	0	0	10 + 2 from a recognized board in any stream	Basic foundation for studying Inorganic Chemistry

LEARNING OBJECTIVES (LO)

LO-1	To enable students to understand and apply the principles of molecular symmetry by identifying symmetry elements and operations, classifying molecules into appropriate point groups, interpreting multiplication tables, and using symmetry concepts to explain molecular polarity and chirality.
LO-2	To develop the ability to interpret and analyze electronic spectra and reaction mechanisms of transition-metal complexes by applying term symbols, microstate calculations, selection rules, Orgel diagrams, and kinetic principles of coordination chemistry.

LO-3	To understand and apply the principles of structure, bonding, and reactivity in metal π -complexes and organometallic compounds, enabling students to interpret spectroscopic features, analyze bonding modes, and explain key organometallic reaction mechanisms.
LO-4	To equip students with the ability to apply quantum-mechanical principles to chemical bonding by solving fundamental Schrödinger-based models, understanding operator properties, and using approximation methods such as the variation and Hückel approaches to describe molecular structure and hybridization.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Remember the basics of symmetry elements and operations as well as use them to determine the point group of molecules.
CO-2	Determine and remember the terms related to energy levels of the d-orbitals in transition metals as well as the theories and rules that govern the transition of electrons in electronic spectra of transition metals and to predict kinetics of octahedral substitution, evaluate factors affecting hydrolysis.
CO-3	Remember the structure and bonding as well as reaction mechanisms of organometallic compounds.
CO-4	Recognize more aspects of operators in quantum chemistry as well as use the Schrodinger wave equation to determine the energy of complex systems such as hydrogen atom and remember the approximations methods such as variation method and apply it to determine the structure of simple linear conjugated systems and for hybridisations.

Unit-1 MOLECULAR SYMMETRY (15L)

Molecular symmetry: Introduction, symmetry operations and symmetry elements: C_n , σ , S_n , i and E . Point groups for the molecules (excluding S_{2n} and I_h) Multiplication tables of C_{2v} , C_{2h} and C_{3v} point groups. Application of symmetry - Polar molecule - Chiral molecule

Unit-2 ELECTRONIC SPECTRA OF METAL COMPLEXES (15L)

A Electronic spectra:

Term symbol, determination of term symbol of ground state, Russel – Saunders coupling, Calculation of microstates, Pigeon hole diagram P_2 and D_2 configuration Hund 's rule, Hole formalism theory, electronic spectra of metal complexes, Selection rule: -Laporte and spin selection rule, Relaxation in selection rules, Vibronic of coupling Jahn Teller distortion (As factors only). combined Orgel energy level diagram of $d_1 - d_9$, $d_2 - d_8$, $d_3 - d_7$, $d_4 - d_6$ and their spectra.

B Reaction mechanism of transition metal complexes.

Energy profile of a reaction Kinetic application of VBT and CFT. Kinetics of octahedral substitution Acid hydrolysis Factor affecting acid hydrolysis Base hydrolysis, conjugate base mechanism

Unit-3 METAL π – COMPLEXES AND REACTION OF ORGANOMETALLIC COMPOUNDS. (15L)

A Metal π – complexes: Metal carbonyl structure and bonding of polynuclear metal carbonyls, $Fe_2(CO)_9$, $Fe_3(CO)_{12}$, $Co_2(CO)_8$, $Mn_2(CO)_{10}$, $Ir_4(CO)_{12}$, $Co_4(CO)_{12}$ Vibrational spectra of metal carbonyl for bonding and structural illustration. Structure and

bonding of metal nitrosyl, metal carbonyl hydrides.

B Reaction of Organometallic compounds:

Ligand substitution, Oxidative addition, and Reductive elimination. σ (Sigma) bond metathesis 1, 2-Insertion and β -hydride elimination α , γ and δ -hydride elimination and cyclometallation.

Unit-4 **QUANTUM CHEMISTRY AND BONDING**

A Quantum chemistry:

Hermitian operator, Theorems concerning Hermitian operator, Schrodinger equation for particle confined in a three-dimensional box, The Schrodinger equation in spherical polar coordinates for hydrogen atom. Separation of variables, Solution of Φ equation.

B Quantum chemistry for bonding:

Variation principle, Solution of secular equation, HMO treatment to ethylene molecule, allylic cation, allylic free radical and allylic anion, Hybridization: - Hybridization wave functions of Sp , Sp^2 and Sp^3 .

Suggestive Reading:

1. "Symmetry and Spectroscopy of Molecules" by K. Veera Reddy 2nd edition New Age International publisher.
2. "Concise Inorganic Chemistry", by J.D. Lee, Wiley India Publication, 5th Edition, 1996, Reprint 2011.
3. "Selected Topics in Inorganic Chemistry" by W.V. Malik, G.D. Tuli, R.D. Madan, S.Chand & Co. Ltd., New Delhi, 7th Edition, 2007
4. "Shriver & Atkins' Inorganic Chemistry" by Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, Oxford University Press, 2011.
5. "Advanced Inorganic Chemistry" by F.A. Cotton and Wilkinson G.; John Wiley, 5th Edition (1988).
6. "Introductory Quantum Chemistry" by A.K. Chandra, Tata- McGraw Hill Pub. Co. Ltd., New Delhi, 4th Edition.
7. "Quantum chemistry" by R.K. Prasad; New Age International, 4th Edition (2010).
8. "Inorganic Chemistry: Principles of Structure and Reactivity" by Huheey 4th edition Pearson, 2006
9. "Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution" by Basola and Pearson 2nd edition, 1967

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FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

**BSc. (Hons.) Chemistry
Category – VI**

Major Course- Analytical Chemistry-II (Theory)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Perquisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
CHMC662C Analytical Chemistry-II	4	0	0	10 + 2 from a recognized board in any stream	Basic foundation for studying Analytical Chemistry

LEARNING OBJECTIVES (LO)	
LO-1	Identify and classify different types of errors (systematic, random, gross) and suggest methods for their minimization. And applying statistical tools such as Q-Test, Student's t-Test, and F-Test to validate analytical results.
LO-2	To compare multiple batch extractions, counter-current extractions, and solid-phase extractions and apply solvent extraction techniques in analytical separations and flow injection analysis. Interpret chromatographic parameters such as partition ratio, retention time, capacity factor, selectivity factor, Van Deemter equation, and resolution. And to

	evaluate column efficiency
LO-3	Understand the principle, equilibria, and applications of ion-exchange chromatography, Gas chromatography and HPLC. Also, to compare different chromatographic methods for qualitative and quantitative analysis.
LO-4	Explain the principle of polarography, Differentiate between types of currents. Apply the Ilkovic equation and determine half-wave potentials. Use Gran's plot and graphical methods. Explain the working principles of ion-selective electrodes (ISEs)
LO-5	To be able to perform titrations of polyprotic acids and bases, Determine carbonate and bicarbonate mixtures. To apply EDTA titration techniques and to understand the role of masking and demasking agents, ligand effects, hydrolysis of EDTA complexes, and auxiliary complexing agents.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	To determine various types of fundamentals of errors associated with data; its minimization Solvent Extraction Separation associated with solid phase and flow injection analysis.
CO-2	To learn about chromatographic methods, Ion exchange chromatography, Gas chromatography, HPLC, Instrumentation
CO-3	To learn basics of Polarography and Potentiometry chemistry
CO-4	To learn about Acid Base Titrations and Complexometric titration

Unit-1 ERRORS AND TREATMENT IN QUANTITATIVE ANALYSIS (15L)

- A** Errors and treatment of Analytical data
Significant figures, Accuracy and precision, Types of errors and minimization of errors. Ways of expressing accuracy and precision. Rejection of a result, Test of significance (Q-Test, Student t-Test and F-Test) correlation coefficient. Literature of Analytical Chemistry.
- B** Solvent Extraction Separation
The separation efficiency of metal chelates, Analytical separations, Multiple batch extractions, Counter current extractions, Solid Phase extractions and Solvent extraction by Flow injection analysis.

Unit-2 CHROMATOGRAPHIC METHODS (15L)

- A** Chromatographic methods
General principle of chromatographic separations, classification of chromatographic techniques, Theory of column efficiency in chromatography - Partition Ratio, Retention time, Capacity Factor, Selectivity Factor, Van Demeter equation and Resolution in Chromatography.

- B** Special Chromatographic techniques.
Ion exchange chromatography (Ion Exchange equilibria, Types of Ion Exchangers and ion-exchange capacity, Application of Ion exchange chromatography). Gas Chromatography Principle and Instrumentation. High Performance Liquid Chromatography (HPLC) Principle and Instrumentation.
- Unit-3 ELECTRO ANALYTICAL TECHNIQUES (15L)**
- A** Polarography
Introduction, Principle, electrode, Types of currents, Determination of half wave potential, Ilkovic equation, methods of determining concentration (Standard addition method and Calibration method)
- B** Potentiometry
The scope of potentiometric titrations, Precipitation and neutralization titrations, Graphical method including Gran's plot for selecting end point, Differential titration, Dead stop titration, Ion selective Electrode, various types of Ion selective Electrodes and use of Calcium ion selective electrode.
- Unit-4 ACID BASE TITRATIONS AND COMPLEXOMETRIC TITRATION**
- A** Acid Base Titrations
Titration of polyprotic acids and their salts, Buffer calculations for polyprotic acids, Titration of sodium carbonate- a diprotic base, determination of carbonate and bicarbonate mixtures, determination of boric acid and sodium borate in mixture
- B** Complexometric titration
EDTA titration techniques-Direct, Back, Displacement and Indirect Titration, Masking, Demasking agent, ligand effect and Hydrolysis of EDTA complex, Auxiliary complexing agent- EDTA titration with an auxiliary complexing agent. (ii)Quantum theory, Instrumentation, Application of Raman spectra

Suggestive Reading:

1. "Analytical Chemistry" by Gary D. Christian, John Wiley & Sons, INC, New York, 6th Edition, 2007.
2. "Fundamentals of Analytical Chemistry" by D. A. Skoog, D. M. West and F. J. Holler, 10th Edition, Cengage Learning, 2022.
3. Quantitative Chemical Analysis: Daniel C. Harris, 9th Edition W H Freeman, New York. 2015
4. "Ion exchange and solvent extraction of metal compounds" by Y. Marcus, A.S. Kertes, Wiley, Interscience.
5. "Chromatography: Principles and Instrumentation (Chemical Analysis: A Series of Monographs on Analytical Chem) : [Mark F. Vitha](#) Wiley, 2016
6. Basic Concepts of Analytical Chemistry; S M Khopkar New Age International, 2007
7. "Quantitative Analysis", by R.A. Day, A.L. Underwood, Prentice-Hall of India Pvt. Ltd., New Delhi, Sixth Edition, 2004.

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FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

**BSc. (Hons.) Chemistry
Category – VI**

Major Course-3: Chemistry lab experiments -VI

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Perquisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
CHMC663L Chemistry lab experiments -VI	0	0	4	10 + 2 from a recognized board in any stream	Basic Knowledge of Chemistry Laboratory work

LEARNING OBJECTIVES (LO)

LO-1	To enable students to systematically separate binary organic mixtures using classical separation techniques and to identify individual components through physical constants, chemical tests, sodium fusion analysis, and derivative formation.
LO-2	To develop students' ability to determine reaction order using graphical methods and to accurately analyze chemical systems using instrumental techniques such as pH-metry, potentiometry, conductometry, and colourimetry for quantitative measurement.
LO-3	To enable students to perform accurate quantitative estimations of metal ions and inorganic analytes using classical volumetric and complexometric titration methods, and to interpret results to determine composition, purity, and analyte concentration in various samples.

COURSE OUTCOMES (CO)

On Completion of this course, the student will be able to	
CO-1	Separate a mixture of organic compounds based on their nature and identify them qualitatively.
CO-2	Apply the principles of conductometry, chemical kinetics, pHmetry, Potentiometry and colorimetry to perform chemical analysis.
CO-3	Use the principles of quantitative analysis and determine the amount of metal ions in mixtures using volumetric analysis.

Practical (Organic, Physical and Volumetric Practicals)

[A] Organic: Organic separation and Identification:

Separation of Binary Mixtures and Identification (Minimum 8 Mixtures)

- (1) Solid + Solid (4 Mixtures)
- (2) Solid + Liquid (2 Mixtures)
- (3) Liquid + Liquid (2 Mixtures)

One Mixture from each of the following should be given Acid-Base, Acid-Phenol, Acid-Neutral, Phenol-Base, Phenol-Neutral, Base-Neutral, and Neutral-Neutral.

Water soluble compounds are included. Identification of separated organic compound must be done by physical and chemical tests, sodium fusion test, M.P / B.P., derivatives and crystallization.

[B] Physical: (Kinetics and Instruments)

(I) **Kinetics:** Investigate the order of reaction in the following experiments by graphical method,

- (1) Reaction between $K_2S_2O_8$ and KI ($a = b$)
- (2) Reaction between $KBrO_3$ and KI ($a \neq b$)
- (3) Reaction between H_2O_2 and HI ($a = b$)

(II) Instruments:

- (1) Titration of unknown strength of HCl with standard NaOH solution using pH meter.
- (2) To determine the concentration of CrO_4^{2-} and Ni^{2+} in solution by colourimetry.
- (3) Titration of a mixture of HCl and CH_3COOH potentiometrically.
- (4) Determination of normality and amount of given halide by conductometric titration.

[C] Volumetric Analysis:

- (1) Estimation of Fe^{3+} by EDTA (Back Titration)
- (2) Estimation of Zn^{2+} and Cd^{2+} in a mixture by EDTA.
- (3) Estimation of Brass (Cu) Volumetrically.
- (4) Estimation of German silver alloy volumetrically (Cu, Ni, Zn)
- (5) Estimation of Mn^{2+} in the presence of oxidizable agents.
- (6) Estimation of sulphate using barium precipitation and back titration.
- (7) Estimation of phosphate ions (via molybdenum blue or back titration)
- (8) Estimation of aluminium in antacids using complexometric titration.
- (9) Estimation of $Mg(OH)_2$ in milk of magnesia.
- (10) Determination of percentage purity of H_2O_2 solution by Iodometry method.

Suggestive Reading:

1. Vogel's Text book of Practical Organic Chemistry by A.I. Vogel/Furniss et al, Pearson Education India, 2011
2. Practical Organic Chemistry by Mann & Saunders Publisher. Pearson Education India Edition 4th ; Publication date. 1 January 2009.
3. Systematic Practical Organic Chemistry by B. D. Khosla, R. Garg, Gulati R. Chand & Co.: New Delhi (2011).
4. Practical Organic Chemistry by O. P. Agarwal Krishna Prakashan, 2006
5. Practical physical Chemistry by B.Viswanthan and P.S. Raghavan Viva Books Private Limited, 2005
6. Advance practical Physical Chemistry by. J.B. Yadav Edition, 16.Goel Pub., 2006
7. Practical physical Chemistry by A. M. James and F.E. Prichard edition 3, Longman, 1974
8. Instrumental Methods on Chemical Analysis by Willard, Merritt, Dean Pub. Van Nostrand, 1974
9. Quantitative Chemical Analysis by Raghuvansi and Siddiqui pub **Pearson Education**.
10. Practical Volumetric Analysis by D.C. Harris 7th edition (Newyork) W.H. Freeman & Co. (2006)

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FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

**BSc. (Hons.) Chemistry
Category – VI**

Minor Course: Nano and Material Science

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Perquisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
CHMN661C Nano and Material Science	4	0	0	10 + 2 from a recognized board in any stream	Basic foundation for studying nano and material

LEARNING OBJECTIVES (LO)

LO-1	To learn the fundamental properties Optical, magnetic and chemical along with the synthesis of nanomaterial by different approaches like top down , bottom up and self-assembly
LO-2	To learn the types of nano material 0-D . 1-D and 2-D
LO-3	To understand principle and characterization of nano materials by various instrumental techniques like SEM, TEM, SPM, AFM XRD etc
LO-4	To understand the constructions and working of various types of batteries, capacitors and conducting polymers used as the sustainable energy storage devices
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Remember and recognize the fundamentals of nanotechnology and nanomaterials
CO-2	Remember and recognize the characterization techniques for nanomaterials

CO-3	Recognize the fundamentals of fuel cells and energy storage devices
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UNIT-1 INTRODUCTION AND PREPARATION OF NANOMATERIALS (15L)

Introduction to Nanomaterials, Optical, magnetic and chemical properties of Nanomaterials, Preparation of Nanoparticles: Chemical Approaches: Chemical reduction; Sonochemical synthesis; Sol-Gel Synthesis; Self-assembly. Physical Approaches: Aerosol spray; Gas condensation; Laser vaporization and vapour deposition; Sputtering.

Unit-2 NANOSTRUCTURED MATERIALS (15L)

Quantum dots, wells & wires; Carbon Nanotubes (CNTs): Single walled carbon nanotubes (SWNTs), Multiwalled carbon nanotubes (MWNTs), Graphene, Fullerenes, Metal/Oxide nanoparticles (NPs), Nanorods, Nanotubes and Nanofibers, Semiconductor quantum dots, Polymer NPs.

Unit-3 CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS (15L)

- A Characterization techniques for Nanomaterials-I
Particle size Analyzer (Laser scattering), Optical Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunnel Microscopy (STM).
- B Characterization techniques for Nanomaterials-II
X-ray Diffraction (XRD), Auger Emission Spectroscopy, Electron Spectroscopy for Chemical analysis (ESCA)

Unit-4 SUSTAINABLE ENERGY STORAGE DEVICES

- A Lithium-Ion Batteries: Classification based on cathode and anode materials, Working Principle: Charge/discharge cycles, role of the electrolyte. Critical Components and Materials: Anode Materials: Graphite, silicon, lithium titanate; Cathode Materials: Layered oxides, spinel oxides, Electrolytes: Organic solvents with lithium salts, Separators: Microporous polymer membranes, Solid electrolytes, Li-ion battery vs lead-acid battery.
- B Supercapacitors- Working principle of supercapacitor, Electric double layer capacitance and Pseudo capacitance, types of supercapacitors, cycling and performance characteristics, Electrode materials: Carbon materials (activated carbon, CNTs, graphene), metal oxides/sulfides, conducting polymers, difference between battery and supercapacitors, device fabrication

Suggestive Reading:

1. "Introduction to Nanotechnology" by Charles P. Poole, Jr. and Frank J. Owens; Wiley Student Edition, 2008
2. "Nanostructures and Nanomaterials: Synthesis, Properties and Applications" by G. Cao, ICP, London, 2004.
3. "Nanobiotechnology, Concepts, Applications and perspectives" by C. M. Niemeyer and C. A. Mirkin, WILEY-VCH, Verlag GmbH & Co, 2004.
4. "Nano - The essentials" by T. Pradeep, Tata McGraw Hill, New Delhi, 2007.
5. "NANOTECHLOGY-basic science and emerging technologies " by Mick Wilson, KamaliKannagaraet.al., University of new south wales press ltd,2008.
6. "Nanomaterials" by A.K. Bandyopadhyay; New Age International Publishers 2nd edition, 2010.