

# University of Mumbai



No. AAMS\_UGS/ICC/2024-25/07

## CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. UG/73 of 2018-19 dated 06<sup>th</sup> July, 2018 relating to the revised syllabus as per the (CBCS) for the Chemistry of T.Y.B.Sc. Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical Chemistry (Sem -V & VI) (3 and 6 units) including Applied Component Drugs and Dyes, Heavy Fine Chemicals and Petrochemicals.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 11<sup>th</sup> May, 2024 and subsequently passed by the Board of Deans at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.10 (R) have been accepted by the Academic Council at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.10 (R) and that in accordance therewith, the revised syllabus for T.Y.B.Sc. (Physical Chemistry) – Sem V & VI (CBCS) has been brought into force with effect from the academic year 2024-25.

(The said circular is available on the University's website [www.mu.ac.in](http://www.mu.ac.in)).

MUMBAI – 400 032  
25<sup>th</sup> June, 2024

*Baliram*  
(Prof. (Dr.) Baliram Gaikwad)  
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.10 (R) /24/05/2024

Copy forwarded with Compliments for information to:-

- 1) The Dean, Faculty of Science & Technology,
- 2) The Chairman, Board of Studies Chemistry,
- 3) The Director, Board of Examinations and Evaluation,
- 4) The Director, Board of Students Development,
- 5) The Director, Department of Information & Communication Technology,
- 6) The Co-ordinator, MKCL,
- 7) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),
- 8) The Deputy Registrar, Result Unit,
- 9) The Deputy Registrar, College Affiliations Development Department (CAD)

**Copy to :-**

- 1. The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
- 2. The Deputy Registrar, College Affiliations & Development Department (CAD),**
- 3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
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- 5. The Deputy Registrar, Executive Authorities Section (EA),**
- 6. The Deputy Registrar, PRO, Fort, (Publication Section),**
- 7. The Deputy Registrar, (Special Cell),**
- 8. The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
- 9. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

**They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.**

- 1. P.A to Hon'ble Vice-Chancellor,**
- 2. P.A Pro-Vice-Chancellor,**
- 3. P.A to Registrar,**
- 4. All Deans of all Faculties,**
- 5. P.A to Finance & Account Officers, (F.& A.O),**
- 6. P.A to Director, Board of Examinations and Evaluation,**
- 7. P.A to Director, Innovation, Incubation and Linkages,**
- 8. P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
- 9. The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
- 10. The Director of Board of Student Development,**
- 11. The Director, Department of Students Welfare (DSD),**
- 12. All Deputy Registrar, Examination House,**
- 13. The Deputy Registrars, Finance & Accounts Section,**
- 14. The Assistant Registrar, Administrative sub-Campus Thane,**
- 15. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
- 16. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
- 17. The Assistant Registrar, Constituent Colleges Unit,**
- 18. BUCTU,**
- 19. The Receptionist,**
- 20. The Telephone Operator,**
- 21. The Secretary MUASA**

**for information.**

# University of Mumbai



**Revised Syllabus for  
T.Y.B.Sc. (Physical Chemistry)  
Semester – (Sem V and VI)  
(Choice Based Credit System)**

**(With effect from the academic year 2024-25)**

# University of Mumbai



## Syllabus for Approval

<b>O: _____</b> <b>Title of Course</b>	T.Y.B.Sc. (Physical Chemistry)
<b>O: _____</b> <b>Eligibility</b>	As per University Ordinance
<b>R: _____</b> <b>Passing Marks</b>	40%
<b>No. of years/Semesters:</b>	Three
<b>Level:</b>	UG
<b>Pattern:</b>	Semester
<b>Status:</b>	Revised
<b>To be implemented from Academic Year :</b>	From Academic Year: 2024-25

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# Preamble

## 1) Introduction

The B.Sc (Chemistry) program is meticulously structured to foster a deep understanding of chemical principles and their real-world applications. The curriculum is a blend of theoretical knowledge and hands-on experience, ensuring that students not only grasp the core concepts but also develop a passion for the subject. With a focus on continuous assessment through quizzes, class tests, and assignments, the program emphasizes the importance of a strong conceptual foundation. This approach is complemented by practical experiments, where theoretical knowledge is applied, enhancing the learning experience and preparing students to tackle the multifaceted challenges in the field of chemistry.

## 2) Aims and Objectives

The B.Sc (Chemistry) program is structured to equip students with a comprehensive understanding of chemical principles and their real-world applications. It aims to foster a deep appreciation for the subject, encouraging students to engage in critical thinking and problem-solving. By integrating theoretical knowledge with practical skills, the course prepares graduates for diverse careers in research, industry, education, and beyond, contributing to their holistic academic and professional growth.

## 3) Learning Outcomes

A strong foundation in the fundamental principles of Physical, Inorganic, organic, and Analytical chemistry is essential for a successful career in the sciences. Continuous learning and self-improvement are critical for staying current in the ever-evolving field of chemistry. A curiosity-driven approach to scientific inquiry fosters innovation and discovery. Identifying potential career paths in chemistry-related fields opens up a world of opportunities in diverse industries. Applying acquired skills to entry-level positions can lead to significant advancements in sectors like pharmaceuticals, materials science, and environmental science.

## 4) Any other point (if any)

The program is meticulously designed to lay a solid foundation in the subject, equipping students with essential skills and knowledge. Through a blend of theoretical understanding and practical application, the curriculum aims to fortify the students' grasp of the basics, ensuring they are well-prepared for advanced study or professional application in the field. This foundational strength is crucial for their academic and career progression, providing a robust platform from which they can build expertise and specialization.

# T.Y.B.Sc. CHEMISTRY (6 UNITS)

Choice Based Credit System

To be implemented from the Academic year 2024-2025

SEMESTER V

PHYSICAL CHEMISTRY (USCH 501)

COURSE CODE: USCH501

CREDITS: 02

LECTURES: 60

UNIT	TOPIC	NO. OF LECTURES
UNIT-I	<b>1.0 Molecular Spectroscopy</b>	<b>15 L</b>
	<b>1.1 Introduction</b> Definition of Spectroscopy, Electromagnetic radiation, Inter-conversion of units, Electromagnetic Spectrum, Molecular energy levels, <b>1.2 Rotational Spectroscopy</b> Dipole moment and Polarisation of bond, Permanent dipole moment and induced dipole moment. Definition and conditions of rotational spectra, Bond length of simple diatomic molecule (rigid rotor). Rotational spectrum of a diatomic molecule, Isotopic shift in rotational spectra, limitations of rotational spectra, applications of rotational spectra. (Numerical expected) <b>1.3 Vibrational Spectrum</b> Definition and conditions of vibrational spectra, modes of vibrations, Hookes law, vibrational frequency, force constant, zero point energy, vibrational spectra of simple harmonic oscillator, vibrational spectra of simple unharmonic oscillator, hot band. Infrared spectra of simple molecules like H <sub>2</sub> O and CO <sub>2</sub> , Applications of vibrational spectroscopy. (Numerical expected) <b>1.4 Raman Spectroscopy</b> Raman phenomenon, Raman shift, quantum theory of Raman effect, rule of mutual exclusion, comparative study of IR and Raman spectra, Applications of Raman spectroscopy. (Numerical expected on Raman Shift)	
UNIT-II	<b>2.0 Chemical Thermodynamics</b>	<b>10 L</b>
	<b>2.1.1 Colligative Properties:</b> Vapour pressure and relative lowering of vapour pressure, Measurement of lowering of vapour pressure- Static and Dynamic method. (Numerical Expected) <b>2.1.2 Solution of Solid in Liquid :</b> <b>2.1.2.1</b> Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute. (Numerical Expected) <b>2.1.2.2</b> Depression in freezing point of a solution, thermodynamic derivation relating	

	<p>the depression in the freezing point of a solution and molar mass of the non-volatile solute, Rast Method. (Numerical expected)</p> <p><b>2.1.3 Osmotic Pressure:</b> Introduction, thermodynamic derivation of Vant Hoff factor, Measurement of Osmotic Pressure – Berkeley and Hartley’s Method, Reverse Osmosis. (Numerical expected)</p>	
	<b>2.2 Chemical Kinetics</b>	<b>5 L</b>
	<p><b>2.2.1 Collision Theory of Reaction Rates:</b> Molecular Activation and Energy of Activation, Application of collision theory w.r.t. Bimolecular reaction (derivation not expected), Collision theory w.r.t. Unimolecular reaction (Lindeman theory) (derivation expected), Demerits of collision theory.</p> <p><b>2.2.2</b> Classification of reaction as slow, fast and ultra-fast, Study of kinetics of fast reactions by Stop flow method and Flash photolysis. (derivation not expected)</p>	
<b>UNIT-III</b>	<b>3.0 Nuclear Chemistry</b>	<b>15 L</b>
	<p><b>3.1 Introduction:</b> Radioactive substance, radioactivity, Types of nuclear radiations Basic terms-radioactive constants (decay constant, half-life and average life) and units of radioactivity.</p> <p><b>3.2 Detection and Measurement of Radioactivity:</b> Detection and measurement of nuclear radiations using G.M. Counter and Scintillation Counter.</p> <p><b>3.3 Radioactive Equilibrium, difference between chemical equilibrium and radioactive equilibrium</b> (Numerical expected)</p> <p><b>3.4 Application of use of radioisotopes as Tracers:</b> Chemical reaction mechanism, age determination- dating by <math>C^{14}</math>.</p> <p><b>3.5 Nuclear Transmutation:</b> Nuclear transmutation (one example for each projectile), artificial radioactivity, Q- value of nuclear reaction, threshold energy. (Numerical expected)</p> <p><b>3.5 Fission Process:</b> Fissile and fertile material, chain reaction, factor controlling fission process, multiplication factor and critical size or mass of fissionable material, Nuclear reactor: Essential parts of nuclear reactor, power reactor</p> <p><b>3.6 Fusion Process :</b> Thermonuclear reactions occurring on stellar bodies and earth</p>	
<b>UNIT-IV</b>	<b>4.1 Surface Chemistry</b>	<b>6L</b>
	<b>4.1.1 Adsorption:</b> Physical and Chemical Adsorption, types of adsorption isotherms, Langmuir’s adsorption isotherm (Postulates and derivations expected). B.E.T. equation for multilayer adsorption, (derivation not expected), Determination of surface area of an adsorbent using B.E.T. equation.	
	<b>4.2 Colloidal State</b>	<b>9L</b>
	<p><b>4.2.1 Introduction to colloids:</b> Dispersed phase and dispersion medium, types of colloids</p> <p><b>4.2.2 Electrical Properties:</b> Origin of charges on colloidal particles, Concept of electrical double layer, Zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena – Electrophoresis, Electro-osmosis, Streaming potential, sedimentation</p>	

potential, Donnan Membrane Equilibrium.

**4.2.3 Colloidal Electrolytes:** Introduction, micelle formation

**4.2.4 Surfactants:** Classification and applications of surfactants in detergents and food industry.

**Reference Books :**

1. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn., Colin N Banwell and Elaine M McCash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.
2. The Elements of Physical Chemistry, P.W. Atkins, 2<sup>nd</sup> Edition, Oxford University Press Oxford.
3. Principles of Physical Chemistry B.R. Puri, L.R. Sharma, M.S. Pathania, VISHAL PUBLISHING Company, 2008.
4. Physical Chemistry, P.C. Rakshit, 6<sup>th</sup> Edition, 2001, Sarat Book Distributors, Kolkata.
5. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3<sup>rd</sup> edition, John Wiley & Sons, Inc [part 1]
6. Physical Chemistry, G. Castellan, 3<sup>rd</sup> edition, 5<sup>th</sup> Reprint, 1995 Narosa Publishing House.
7. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2<sup>nd</sup> Edition, 1<sup>st</sup> Indian reprint, 2006 Springer
8. Physical Chemistry, G.M. Barrow, 6<sup>th</sup> Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
9. Physical Chemistry, Ira Levine, 5<sup>th</sup> Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
10. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.
11. Essentials of Nuclear Chemistry, Arnikar, Hari Jeevan, New Age International (P) Ltd., Publishers, 2011.
12. Chemical Kinetics, K. Laidler, Pearson Education India, 1987.
13. Modern Nuclear Chemistry Hardcover by Walter D. Loveland (Author), David J. Morrissey, Glenn T. Seaborg, Wiley.
14. A Textbook of Physical Chemistry - Dynamics of Chemical Reactions, Statistical Thermodynamics, Macromolecules and Irreversible Processes| Volume 5, 3<sup>rd</sup> Edition by K L Kapoor, McGraw Hill Education.

**T.Y.B.Sc**  
**Physical Chemistry Practical**  
**SEMESTER V**

COURSE CODE: USCHP01

CREDITS: 02

**NON-INSTRUMENTAL EXPERIMENT**

**Colligative properties**

1) To determine the molecular weight of compound by Rast Method.

**Chemical Kinetic**

2) To interpret the order of reaction graphically from the given experimental data and calculate the specific rate constant

**Surface phenomena**

3) To investigate the adsorption of acetic acid on activated charcoal and test the validity of Freundlich adsorption isotherm.

**INSTRUMENTAL EXPERIMENT**

**Potentiometry**

4) To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and ceric sulphate potentiometrically

**Conductometry**

5) To determine the velocity constant of alkaline hydrolysis of ethyl acetate by conductometric method.

**pH- metry**

6) To determine acidic and basic dissociation constants of amino acid and hence to isoelectric point.

**Reference books**

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. Experimental Physical Chemistry By V.D.Athawale.
6. Senior Practical Physical Chemistry By: B. D. Khosla, V. C. Garg and A. Gulati, R Chand and Co.. 2011

## T.Y.B.Sc. CHEMISTRY (6 UNITS)

Choice Based Credit System

To be implemented from the Academic year 2024-2025

## SEMESTER VI

## PHYSICAL CHEMISTRY (USCH 601)

COURSE CODE: USCH601

CREDITS: 02

LECTURES: 60

UNIT	TOPIC	NO. OF LECTURES
UNIT-I	<b>1.1 Electrochemistry</b>	7 L
	<p><b>1.1.1 Activity and Activity Coefficient:</b> Lewis concept, ionic strength, Mean ionic activity and mean ionic activity coefficient of an electrolyte, expression for activities of electrolytes. Debye Huckel limiting law (No derivation) (Numerical expected)</p> <p><b>1.1.2 Classifications of cells:</b> Chemical cells and Concentration cells. Chemical cells, Electrode concentration cells, Liquid junction potential, Electrolyte concentration cells with and without transference</p>	
	<b>1.2 Applied Electrochemistry</b>	8 L
	<p><b>1.2.1 Polarization :</b> Concentration polarization and its elimination</p> <p><b>1.2.2 Decomposition Potential and Overvoltage:</b> Introduction, experimental determination of decomposition potential, Factors affecting decomposition potential.</p> <p><b>1.2.3 Over Voltage:</b> Experimental determination of over-voltage. Hydrogen over voltage, Tafel's equation for hydrogen overvoltage. (Numerical expected)</p>	
UNIT-II	<b>2.1 Polymers</b>	10 L
	<p><b>2.1.1 Recapitulations:</b> Basic terms of polymer</p> <p><b>2.1.2 Classification of polymer:</b> Classification based on Source, Thermal response, physical properties</p> <p><b>2.1.3 Method of determination molar masses of polymer:</b> by Ultra-Centrifuge method (limiting velocity method), Viscosity method using Ostwald Viscometer (derivation and numerical expected),</p> <p><b>2.1.4 Light Emitting Polymer:</b> Introduction, Characteristics, Method of preparation and applications.</p> <p><b>2.1.5 Antioxidants and Stabilizer:</b> Antioxidants, Ultraviolet stabilizers, Colorants, Antistatic agent.</p>	

	<b>2.2 Phase Equilibria</b>	<b>5 L</b>
	<p><b>2.2.1 Introduction:</b> Gibbs Phase rule and terms involved it, condensed phase rule.</p> <p><b>2.2.2 Three component System-</b> Introduction of three component system and explanation of phase diagram with example of</p> <p>Type I - Formation of one pair of partially miscible liquids.</p> <p>Type II- Formation of two pairs of partially miscible liquids</p> <p>Type III – Formation of three pairs of partially miscible liquids.</p>	
<b>UNIT III</b>	<b>3.1 Basic of Quantum Chemistry</b>	<b>10 L</b>
	<p><b>3.1.1. Classical mechanics:</b> Introduction, limitation of classical mechanics, Black body radiation, photoelectric effect, Compton effect.</p> <p><b>3.1.2 Quantum mechanics:</b> Introduction, Planck's theory of quantization, wave particle duality, de-Broglie's equation, Heisenberg's uncertainty principle. (Numerical expected)</p> <p><b>3.1.3 Progressive and standing waves</b> – Introduction, boundary conditions, Schrodinger's time independent wave equation (No derivation expected), interpretation and properties of wave function.</p> <p><b>3.1.4 Quantum mechanics:</b> State function and its significance, Concept of operators – definition, addition, subtraction and multiplication of operators, commutative and non-commutative operators, linear operator, Hamiltonian operators, Eigen function and Eigen value. (Numerical expected)</p>	
	<b>3.2 Renewable Energy Resources</b>	<b>5 L</b>
	<p><b>3.2.1 Renewable energy resources:</b> Need of renewable energy resources</p> <p><b>3.2.2 Solar energy:</b> Solar cells, Photovoltaic effect, Differences between conductors, semiconductors, insulators and its band gap, Semiconductors as solar energy converters, Silicon solar cell.</p> <p><b>3.2.3 Hydrogen:</b> Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium.</p>	
<b>UNIT-IV</b>	<b>4.1 NMR -Nuclear Magnetic Resonance Spectroscopy</b>	<b>8 L</b>
	<p>4.1.1 Principle : Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in NMR (spin-spin relaxation and spin- lattice relaxation)</p> <p><b>Instrumentation :</b> NMR Spectrometer</p>	
	<b>4.2 ESR-Electron Spin Resonance Spectroscopy</b>	<b>7 L</b>
	<p><b>4.2.1. Principle:</b> Fundamental equation, g-value- dimensionless constant or electron g – factor, hyperfine splitting.</p> <p><b>4.2.2 Instrumentation:</b> ESR spectrometer, ESR spectrum of hydrogen and deuterium</p>	

## References Books :

1. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2<sup>nd</sup> Edition, 1<sup>st</sup> Indian reprint, 2006 Springer.
2. Physical Chemistry, Ira Levine, 5<sup>th</sup> Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
3. Physical Chemistry, P.C. Rakshit, 6<sup>th</sup> Edition, 2001, Sarat Book Distributors, Kolkata.
4. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3<sup>rd</sup> edition, John Wiley & Sons, Inc [part 1]
5. Physical Chemistry, G. Castellan, 3<sup>rd</sup> edition, 5<sup>th</sup> Reprint, 1995 Narosa Publishing House.
6. Physical Chemistry, G.M. Barrow, 6<sup>th</sup> Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
7. The Elements of Physical Chemistry, P.W. Atkins, 2<sup>nd</sup> Edition, Oxford University Press Oxford.
8. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.
9. Principles of Physical Chemistry B.R. Puri, L.R. Sharma, M.S. Pathania, Vishal Publishing Company, 2008.
10. Textbook of Polymer Science, Fred W Bilmeyer, John Wiley & Sons (Asia) Ple. Ltd., Singapore, 2007.
11. Polymer Science, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.
12. S. Glasstone, Thermodynamics for Chemists, Affiliated East- West Press, New Delhi, 1964.
13. D. N. Bajpai, Advanced Physical Chemistry, S. Chand 1<sup>st</sup> Edn. 1992.
14. Quantum Chemistry Paperback by Donald A. McQuarrie.

# T.Y. B. Sc. Physical Chemistry Practical

## SEMESTER VI

### PHYSICAL CHEMISTRY

**COURSE CODE: USCHP02**

**CREDITS: 02**

#### NON-INSTRUMENTAL EXPERIMENTS

##### Viscosity

1) To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement

##### Phase equilibria

2) To study phase diagram of three component system water- chloroform/ toluene- acetic acid by weight method.

#### INSTRUMENTAL EXPERIMENTS

##### Potentiometer

3) To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.

4) To determine the Solubility product and solubility of AgCl potentiometrically using chemical cell.

##### Conductometry

5) To titrate a mixture of weak acid and strong acid against strong base and estimate the amount of each acid in the mixture conductometrically.

##### Colorimetry

6) To estimate the amount of Fe (III) in the complex formation with salicylic acid by Static method.

##### Reference Books:

1. Practical Physical Chemistry 3<sup>rd</sup> edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
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## Evaluation Pattern for Semesters V and VI

### Semester End Theory Examination

<b>Internal Continuous Assessment: 25% (25 Marks)</b>	<b>Semester End Examination: 75% (75 Marks)</b>	<b>Duration for End Semester Examination</b>
<b>Continuous Evaluation through:</b> Quizzes, Class Tests, Presentations, Projects, Role Plays, Creative Writings, Assignments, etc.	As per following pattern	2 hrs 30 minutes

### Pattern for Semester End Examination (75 Marks):

1. Duration - This examination shall be of **Two hours and 30 minutes** duration.
2. Theory question paper pattern:
  - a. There shall be **05** questions each of **15 marks**.
  - b. All questions shall be compulsory with internal choice within the questions.

Question	Option	Marks	Based on Units
Q.1	Subjective questions 3 out of 5	15	Unit I
Q.2	Subjective questions 3 out of 5	15	Unit II
Q.3	Subjective questions 3 out of 5	15	Unit III
Q.4	Subjective questions 3 out of 5	15	Unit IV
Q.5	A. True or False (Any Five out of Eight)	05	All Units
	B. Fill in the Blank with correct alternative. (MCQs with Four Options) (Any Five out of Eight)	05	
	C. Match the following (Any Five out of Eight)	05	
Total		<b>75</b>	--

## **Practical**

1. Total Marks for Practical Examination per major component is 50 Marks.
2. Every student shall perform **one experiment** from each Major Component
3. Scheme of Examination:
  - a. Experiment : 40 Marks
  - b. Journal : 05 Marks
  - c. Viva-Voce : 05 Marks

**Total : 50 Marks**

### ***Practical Book/Journal:***

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# University of Mumbai



No. AAMS\_UGS/ICC/2024-25/12

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(The said circular is available on the University's website [www.mu.ac.in](http://www.mu.ac.in)).

MUMBAI – 400 032  
25<sup>th</sup> June, 2024

  
(Prof. (Dr.) Baliram Gaikwad)  
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.15 (R) /24/05/2024

Copy forwarded with Compliments for information to:-

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- 2) The Chairman, Board of Studies **Chemistry**,
- 3) The Director, Board of Examinations and Evaluation,
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- 5) The Director, Department of Information & Communication Technology,
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- 9. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

**They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.**

- 1. P.A to Hon'ble Vice-Chancellor,**
- 2. P.A Pro-Vice-Chancellor,**
- 3. P.A to Registrar,**
- 4. All Deans of all Faculties,**
- 5. P.A to Finance & Account Officers, (F.& A.O),**
- 6. P.A to Director, Board of Examinations and Evaluation,**
- 7. P.A to Director, Innovation, Incubation and Linkages,**
- 8. P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
- 9. The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
- 10. The Director of Board of Student Development,**
- 11. The Director, Department of Students Welfare (DSD),**
- 12. All Deputy Registrar, Examination House,**
- 13. The Deputy Registrars, Finance & Accounts Section,**
- 14. The Assistant Registrar, Administrative sub-Campus Thane,**
- 15. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
- 16. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
- 17. The Assistant Registrar, Constituent Colleges Unit,**
- 18. BUCTU,**
- 19. The Receptionist,**
- 20. The Telephone Operator,**
- 21. The Secretary MUASA**

**for information.**

# University of Mumbai



**Revised Syllabus for**

**T.Y.B.Sc. (Inorganic Chemistry)**

**Semester – (Sem V and VI)**

**(Choice Based Credit System)**

**(With effect from the academic year 2024-25)**

# University of Mumbai



## Syllabus for Approval

O: _____	<b>Title of Course</b>	T.Y.B.Sc. (Inorganic Chemistry)
O: _____	<b>Eligibility</b>	As per University Ordinance
R: _____	<b>Passing Marks</b>	40%
<b>No. of years/Semesters:</b>		Three
<b>Level:</b>		UG
<b>Pattern:</b>		Semester
<b>Status:</b>		Revised
<b>To be implemented from Academic Year :</b>		From Academic Year: 2024-25

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# Preamble

## 1) **Introduction**

The B.Sc (Chemistry) program is meticulously structured to foster a deep understanding of chemical principles and their real-world applications. The curriculum is a blend of theoretical knowledge and hands-on experience, ensuring that students not only grasp the core concepts but also develop a passion for the subject. With a focus on continuous assessment through quizzes, class tests, and assignments, the program emphasizes the importance of a strong conceptual foundation. This approach is complemented by practical experiments, where theoretical knowledge is applied, enhancing the learning experience and preparing students to tackle the multifaceted challenges in the field of chemistry.

## 2) **Aims and Objectives**

The B.Sc (Chemistry) program is structured to equip students with a comprehensive understanding of chemical principles and their real-world applications. It aims to foster a deep appreciation for the subject, encouraging students to engage in critical thinking and problem-solving. By integrating theoretical knowledge with practical skills, the course prepares graduates for diverse careers in research, industry, education, and beyond, contributing to their holistic academic and professional growth.

## 3) **Learning Outcomes**

A strong foundation in the fundamental principles of Physical, Inorganic, organic, and Analytical chemistry is essential for a successful career in the sciences. Continuous learning and self-improvement are critical for staying current in the ever-evolving field of chemistry. A curiosity-driven approach to scientific inquiry fosters innovation and discovery. Identifying potential career paths in chemistry-related fields opens up a world of opportunities in diverse industries. Applying acquired skills to entry-level positions can lead to significant advancements in sectors like pharmaceuticals, materials science, and environmental science.

## 4) **Any other point (if any)**

The program is meticulously designed to lay a solid foundation in the subject, equipping students with essential skills and knowledge. Through a blend of theoretical understanding and practical application, the curriculum aims to fortify the students' grasp of the basics, ensuring they are well-prepared for advanced study or professional application in the field. This foundational strength is crucial for their academic and career progression, providing a robust platform from which they can build expertise and specialization.

# T.Y.B.Sc. CHEMISTRY (6 UNITS)

Choice Based Credit System

To be implemented from the Academic year 2024-25

## Paper II: Inorganic Chemistry

SEMESTER V

<b>Course Code: USCH502</b>	<b>Credits: 02</b>	<b>Lectures: 60</b>
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<b>Unit</b>		<b>Topic</b>	<b>No. of Lectures</b>	<b>Total No. of Lectures</b>
I	1)	<b>Molecular Symmetry</b>	<b>6</b>	<b>15</b>
	2)	<b>Molecular Orbital Theory for heteronuclear diatomic molecules and polyatomic species</b>	<b>9</b>	
II	1)	<b>Structures of Solids</b>	<b>11</b>	<b>15</b>
	2)	<b>Superconductivity</b>	<b>4</b>	
III	1)	<b>Chemistry of Inner Transition Elements</b>	<b>15</b>	<b>15</b>
IV	1)	<b>Chemistry of Non-aqueous Solvents</b>	<b>5</b>	<b>15</b>
	2)	<b>Comparative Chemistry of Group 16</b>	<b>5</b>	
	3)	<b>Comparative Chemistry of Group 17</b>	<b>5</b>	

Unit	Topic	No. of Lectures
<b>Unit I</b>	<b>Molecular Symmetry and Chemical Bond</b>	<b>15</b>
	<b>1.1 Molecular Symmetry</b>	<b>6</b>
	1.1.1 Introduction and Importance of Symmetry in Chemistry. 1.1.2 Symmetry elements and Symmetry operations. 1.1.3 Concept of a Point Group with illustrations using the following point groups :(i) $C_{\infty V}$ (ii) $D_{\infty h}$ (iii) $C_{2V}$ (iv) $C_{3v}$ (v) $C_{2h}$ and (vi) $D_{3h}$ .	
	<b>1.2 Molecular Orbital Theory for heteronuclear diatomic molecules and polyatomic species</b>	<b>9</b>
	1.2.1 Comparison between homonuclear and heteronuclear diatomic molecules. 1.2.2. Heteronuclear diatomic molecules like CO and NO Modified MO diagram for CO. 1.2.3 Application of Molecular orbital theory to Polyatomic species $H_3$ , $H_3^+$ and $AB_2$ molecules such as $BeH_2$ and $H_2O$ (Correlation diagram expected).	
<b>Unit II</b>	<b>Solid State Chemistry</b>	<b>15</b>
	<b>2.1 Structures of Solids</b>	<b>11</b>
	2.1.1 Explanation of terms viz. crystal lattice, lattice point, unit cell and lattice constants. 2.1.2 Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc and fcc lattices. Relationship between density, radius of unit cell and lattice parameters. (Numerical problems expected) 2.1.3 Stoichiometric Point defects in solids (discussion on Frenkel and Schottky defects expected).	
	<b>. 2.2 Superconductivity</b>	<b>4</b>
	2.2.1 Discovery of superconductivity. 2.2.2 Explanation of terms like superconductivity, transition temperature, Meissner effect. 2.2.3 Different types of super conductors viz. conventional superconductors, alkali metal fullerenes, high temperature super conductors. 2.2.4 Brief application of superconductors.	
<b>Unit III</b>	<b>Chemistry of Inner Transition Elements</b>	<b>15</b>
	<b>3.1 Introduction:</b> Position in periodic table and electronic configuration of lanthanides and actinides. <b>3.2 Chemistry of Lanthanides with reference to</b> (i) lanthanide contraction and its consequences (ii) Oxidation states (iii) Ability to form complexes (iv) Magnetic and spectral properties. <b>3.3</b> Occurrence, extraction and separation of lanthanides by (i) Ion Exchange method (ii) Solvent extraction method using TBP . (Principles and technique) <b>3.4</b> Applications of lanthanides	
<b>Unit IV</b>	<b>4. SOME SELECTED TOPICS</b>	<b>15</b>

	<p><b>4.1 Chemistry of Non-aqueous Solvents</b></p> <p>4.1.1 Properties, General classification and importance of non-aqueous solvents.</p> <p>4.1.2 Characteristics and study of liquid ammonia, dinitrogen tetraoxide as non-aqueous solvents with respect to : (i) acid-base reactions and (ii) redox reactions.</p>	<b>5</b>	
	<p><b>4.2 Comparative Chemistry of Group 16</b></p> <p>4.2.1 Electronic configurations, trends in physical properties, allotropy</p> <p>4.2.2 Physico-chemical principles involved in manufacture of sulphuric acid by Contact process.</p>	<b>5</b>	
	<p><b>4.3 Comparative Chemistry of Group 17</b></p>	<b>5</b>	
	<p>4.3.1 Electronic configuration, General characteristics, anomalous properties of fluorine, comparative study of acidity of oxoacids of chlorine w.r.t acidity, oxidizing properties</p> <p>4.3.2 Chemistry of interhalogens with reference to preparations, properties and structures (on the basis of VSEPR theory).</p>		

## Reference Books:

### SEM-V

#### Unit-I

1. Per Jensen and Philip R. Bunker, Fundamentals of Molecular Symmetry, Series in Chemical Physics, Taylor & Francis Group
2. J. S. Ogden, Introduction to Molecular Symmetry, Oxford University Press
3. Derek W. Smith, Molecular orbital theory in inorganic chemistry Publisher: Cambridge University Press
4. C. J. Ballhausen, Carl Johan Ballhausen, Harry B. Gray Molecular Orbital Theory: An Introductory Lecture Note and Reprint Volume Frontiers in chemistry Publisher W.A. Benjamin, 1965
5. Jack Barrett and Mounir A Malati, Fundamentals of Inorganic Chemistry, Affiliated East west Press Pvt. Ltd., New Delhi.
6. Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry. S. Chand &Co Ltd.
7. E books: Molecular symmetry and spectroscopy by Philip Bunker, Molecular symmetry by David Wilock,Essentials of coordination chemistry by Vashishta Bhatt

#### Unit-II

1. Lesley E. Smart, Elaine A. Moore Solid State Chemistry: An Introduction, 2nd Edition CRC Press,
  2. C. N. R. Rao Advances in Solid State Chemistry
  3. R.G. Sharma Superconductivity: Basics and Applications to Magnets
  4. Michael Tinkham ,Introduction to Superconductivity: Vol I (Dover Books on Physics)
  5. R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
  6. Richard Harwood, Chemistry, Cambridge University Press,
  7. Satya Prakash, G.D.Tuli, R.D. Madan, Advanced Inorganic Chemistry. S. Chand & Co Ltd
- E books : Solid state chemistry by Elaine Moore, Smart 5<sup>th</sup> edition, Sperlconductivity by Paolo Mele,

#### Unit-III

1. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.
  2. Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
  3. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
  4. G. Singh, Chemistry of Lanthanides and Actinides, Discovery Publishing House
  5. Simon Cotton, Lanthanide and Actinide Chemistry Publisher: Wiley-Blackwell
- E book: Chemistry Lanthanides and Actinides by G. Singh, Lanthanides and Actinides Chemistry by Simon Cotton, Wiley publication

## Unit-IV

1. B. H. Mahan, University Chemistry, Narosa publishing.
2. R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
3. J. D. Lee, Concise Inorganic Chemistry, 4<sup>th</sup> Edn., ELBS,
4. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, Oxford University Press
5. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.
6. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt., Ltd. (2002).
7. Richard Harwood, Chemistry, chapter 10 Industrial inorganic chemistry
8. Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
9. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993
10. Satya Prakash, G.D. Tuli, R.D. Madan, Advanced Inorganic Chemistry. S. Chand & Co Ltd 2004

E books : Chemistry in Non aqueous solvents by Bernard Tremillon. Springer, Non aqueous Solvent system by Thomas Cudworth

# PRACTICALS SEM V

Course Code: USCHPO2	Credits: 02
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## Course USCHPO2: Inorganic Practicals

(60L)

### **I. Inorganic preparations**

1. Preparation of Potassium diaquobis- (oxalato)cuprate (II)
2. Preparation of Ferrous ethylene diammonium sulphate.
3. Preparation of bisacetylacetonatocopper(II)

**II.** Determination of percentage purity of the given water soluble salt and qualitative detection w.r.t added impurity cation and anion.

Salts of selected transition metal ions viz. Cu, Fe and Ni. Quantitative analysis by titration method. (Iodometry for Cu ions, Complexometry for Ni ions using murexide indicator and Fe ions by redox titration). Qualitative analysis by wet test method.

### **Reference Books (practicals)**

1. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.
2. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N. Dhur & Sons Pvt Ltd .
3. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition.

**T.Y.B.Sc. CHEMISTRY (6 UNITS)**  
Choice Based Credit System

To be implemented from the Academic year 2024-25

**Paper II: Inorganic Chemistry**

**SEMESTER VI**

<b>Course Code: USCH602</b>	<b>Credits: 02</b>	<b>Lectures: 60</b>
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<b>Unit</b>		<b>Topic</b>	<b>No. of Lectures</b>	<b>Total No. of Lectures</b>
<b>I</b>	1)	<b>Tenets of Crystal Field Theory</b>	<b>15</b>	<b>15</b>
<b>II</b>	1)	<b>Molecular orbital theory for coordination compounds</b>	<b>4</b>	<b>15</b>
	2)	<b>Stability of Metal complexes</b>	<b>3</b>	
	3)	<b>Reactivity of Metal complexes</b>	<b>4</b>	
	4)	<b>Electronic spectra of metal complexes</b>	<b>4</b>	
<b>III</b>	1)	<b>Organometallic Compounds of main group metal</b>	<b>6</b>	<b>15</b>
	2)	<b>Metallocenes</b>	<b>5</b>	
	3)	<b>Role of transition metals in Catalysis</b>	<b>4</b>	
<b>IV</b>	1)	<b>Metallurgy</b>	<b>7</b>	<b>15</b>
	2)	<b>Chemistry of Group 18</b>	<b>5</b>	
	3)	<b>Introduction to Bioinorganic Chemistry</b>	<b>3</b>	

Unit	Topic	No. of Lectures
Unit I	<b>Tenets of Crystal Field Theory</b>	15
	1.1 Limitations of Valence Bond Theory. 1.2 Fundamentals of Crystal Field Theory 1.3 Crystal field Splitting of <i>d</i> orbitals in octahedral, square planar and tetrahedral complexes. 1.4 Distortions from the octahedral geometry: (i) effect of ligand field (ii) Jahn-Teller distortions. 1.5 Crystal field splitting parameter $10Dq(\Delta)$ , factors affecting $10 Dq$ , spectrochemical series. 1.6 Crystal field stabilization energy(CFSE), calculation of CFSE for octahedral complexes with $d^0$ to $d^{10}$ metal ion configurations. 1.7 Consequences of crystal field splitting on various properties such as ionic radii, hydration energy of formation of metal complexes of the first transition series. 1.8 Limitations of CFT: Evidences for covalence in metal complexes with respect to (i) intensities of d-d transitions (ii) ESR spectrum of $[\text{IrCl}_6]^{2-}$ (iii) Nephelauxetic effect.	
Unit II	<b>Molecular orbital Theory and properties of coordination compounds</b>	15
	<b>2.1 Molecular orbital Theory</b>	4
	2.1.1 Identification of the central metal orbitals and their symmetry suitable for formation of $\sigma$ bonds with ligand orbitals. 2.1.2 Construction of ligand group orbitals. 2.1.3 Construction of molecular orbitals for $\text{ML}_6$ complex. Examples like $[\text{FeF}_6]^{-4}$ , $[\text{Fe}(\text{CN})_6]^{-4}$ , $[\text{CoF}_6]^{-3}$ , $[\text{Co}(\text{NH}_3)_6]^{+3}$ 2.1.4 Effect of $\pi$ -bonding on complexes .	
	<b>2.2 Stability of Metal-Complexes</b>	3
	2.2.1 Thermodynamic and kinetic perspectives of metal complexes with examples. 2.2.2 Stability constants: stepwise and overall stability constants and their interrelationship. 2.2.3 Factors affecting thermodynamic stability.	

	<b>2.3 Reactivity of metal complexes</b>	<b>4</b>
	2.3.1 Comparison between Inorganic and organic reactions. 2.3.2 Types of reactions in metal complexes. 2.3.3 Study of Inert and labile complexes with respect to $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ and $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ complexes. 2.3.4 Ligand substitution reactions : Associative and Dissociative mechanisms. 2.2.5 Acid hydrolysis, base hydrolysis and anation reactions.	
	<b>2.4 Electronic Spectra</b>	<b>4</b>
	2.4.1 Origin of electronic spectra 2.4.2 Types of electronic transitions in coordination compounds: intra- ligand, Charge transfer and intra-metal transitions. 2.4.3 Selection rules for electronic transitions. 2.4.4 Electronic configuration and electronic micro states, Terms and Term symbols for transition metal ions, rules for determination of ground state term. 2.4.5 Determination of Terms for $p^2$ and $d^1$ electronic configurations.	
<b>Unit III</b>	<b>3.0 Organometallic chemistry</b>	<b>15</b>
	<b>3.1 Organometallic Compounds of main group metal</b>	<b>6</b>
	3.1.1 General characteristics of various types of organometallic compounds, viz. ionic, $\sigma$ -bonded and electron deficient compounds. 3.1.2 General synthetic methods of organometallic compounds : (i) Oxidative-addition, (ii) Metal-metal exchange (trans-metallation), (iii) Carbanion-halide exchange, (iv) Metal-hydrogen exchange (metallation) and (v) Methylene-insertion reactions. 3.1.3 Some chemical reactions of organometallic compounds: (i) Reactions with oxygen and halogens, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents	
	<b>3.2 Metallocenes</b>	<b>5</b>
	Introduction, Ferrocene: Synthesis, properties, structure and bonding on the basis of VBT.	
	<b>3.3 Role of transition metals in Catalysis</b>	<b>4</b>
	3.3.1 Comparison between homogeneous and	

	<p>heterogeneous catalysis</p> <p>3.3.2 Basic steps involved in homogeneous catalysis</p> <p>3.3.3 Mechanism of Wilkinson's catalyst in hydrogenation of alkenes.</p>	
<b>Unit IV</b>	<b>SOME SELECTED TOPICS</b>	<b>15</b>
	<b>4.1 Metallurgy</b>	<b>7</b>
	<p>4.1.1 Types of metallurgies,</p> <p>4.1.2 General steps of metallurgy; Concentration of ore, calcinations, roasting, reduction and refining.</p> <p>4.1.3 Metallurgy of copper: occurrence, physicochemical principles, Extraction of copper from pyrites &amp; refining by electrolysis.</p>	
	<b>4.2 Chemistry of Group 18</b>	<b>5</b>
	<p>4.2.1 Historical perspectives</p> <p>4.2.2 General characteristics and trends in physical and chemical properties</p> <p>4.2.3 Isolation of noble gases</p> <p>4.2.4 Compounds of Xenon fluorides (<math>\text{XeF}_2, \text{XeF}_4, \text{XeF}_6</math>) with respect to preparation and structure (VSEPR)</p> <p>4.2.5 Applications of noble gases</p>	
	<b>4.3 Introduction to Bioinorganic Chemistry.</b>	<b>3</b>
	<p>4.3.1 Essential and non essential elements in biological systems.</p> <p>4.3.2 Biological importance of metal ions such as <math>\text{Na}^+, \text{K}^+, \text{Fe}^{+2}/\text{Fe}^{+3}</math> and <math>\text{Cu}^{+2}</math> (Role of <math>\text{Na}^+</math> and <math>\text{K}^+</math> w.r.t ion pump)</p>	

## References.

### SEM-VI

#### Unit-I:

1. Geoffrey A. Lawrance Introduction to Coordination Chemistry John Wiley & Sons.
2. R. K. Sharma Text Book of Coordination Chemistry Discovery Publishing House
3. R. Gopalan , V. Ramalingam Concise Coordination Chemistry , Vikas PublishingHouse;
4. Shukla P R, Advance Coordination Chemistry , Himalaya Publishing House
5. Glen E. Rodgers, Descriptive Inorganic, Coordination, and Solid-State Chemistry Publisher: Thomson Brooks/Cole
6. Applications of Crystal Field Theory, Christoph Sontag, 2018
7. Crystal field Handbook by D.J. Nonmin  
E book: Crystal Field Theory , Libre Texts chemistry 23.6

#### Unit-II:

1. Ramesh Kapoor and R.S. Chopra, **Inorganic Chemistry**, R. Chand publishers,
2. Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY,
3. Twigg ,Mechanisms of Inorganic and Organometallic Reactions  
Publisher: Springer
4. R.K. Sharma Inorganic Reaction Mechanisms Discovery Publishing House
5. M. L. Tobe Inorganic Reaction Mechanisms Publisher Nelson, 1972.
6. Coordination chemistry- Fred Basolo Ronald Johnson  
Ebook: Coordination chemistry, Sandhya Pimpalpure, Rahmi Jain

#### Unit-III:

1. Cotton, Wilkinson, Murillo and Bochmann, Advanced **Inorganic Chemistry**, 6<sup>th</sup> Edition..
2. H.W. Porterfield, Inorganic Chemistry, Second Edition, Academic Press, 2005
3. Purecell, K.F. and Kotz, J.C., Inorganic Chemistry W.B. Saunders Co. 1977.
4. Robert H. Crabtree ,The Organometallic Chemistry of the Transition Metals, Publication by John Wiley & Sons
5. B D Gupta & Anil J Elias Basic Organometallic Chemistry: Concepts, Syntheses and Applications, University press
6. Ram Charan Mehrotra, Organometallic Chemistry: A Unified Approach, New Age International.

E books: Organometallic chemistry, edited by Hiroshi Nakazawa, Royal society of Chemistry

Organometallic chemistry of Transition metal , Robert Crabtree

#### Unit-IV

1.R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.

2.D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, OxfordUniversity Press

3. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.

4. Jack Barrett and Mounir A Malati, Fundamentals of Inorganic Chemistry, Affiliated East west Press Pvt. Ltd., New Delhi.

5. R.Gopalan, Chemistry for undergraduates. Chapter 18. Principles of Metallurgy.(567-591)

6.Puri ,Sharma Kalia Inorganic chemistry. Chapter 10, Metals and metallurgy.(328-339)Greenwood, N.N. and Earnshaw, Chemistry of the Elements, ButterworthHeinemann. 1997.

7. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.

8. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry PanimaPublishing Company 1994.

9. Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry.S. Chand& Co Ltd

E books: Extractive metallurgy of copper by Mark Schlesinger Manual of Metallurgy by William Greenwood Bioinorganic chemistry by Asim Das, Bioinorganic chemistry, Rosette Roat-Malone

# PRACTICALS SEM VI

Course Code: USCHPO2

Credits: 02

## Course USCHP02: Inorganic Practicals

(60L)

### I. Inorganic preparations

1. Preparation of Tris(acetylacetonato) iron(III)
2. Green synthesis of bis(dimethylglyoximato) nickel(II) complex using nickel carbonate and sodium salt of dmg .
3. Preparation of potassium trioxalato aluminate (III)

### II. Determination of percentage purity of the given water soluble salt and qualitative detection w.r.t added impurity cation and/or anion .

Salts of selected Main group metal ions viz. Mg, Ba, Sr/Ca. Quantitative analysis by titration method. (complexometric titration of all ions using Eriochrome Black T indicator ).

Qualitative analysis by wet test method.

### Reference Books (practicals)

1. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.
2. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N. Dhur & Sons Pvt Ltd .
3. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition.

XXXXXX

### Evaluation Pattern for Semesters V and VI

#### Semester End Theory Examination

<b>Internal Continuous Assessment: 25% (25 Marks)</b>	<b>Semester End Examination: 75% (75 Marks)</b>	<b>Duration for End Semester Examination</b>
<b>Continuous Evaluation through:</b> Quizzes, Class Tests, Presentations, Projects, Role Plays, Creative Writings, Assignments, etc.	As per following pattern	2 hrs 30 minutes

**Pattern for Semester End Examination (75 Marks):**

1. Duration - This examination shall be of **Two hours and 30 minutes** duration.
2. Theory question paper pattern:
  - a. There shall be **05** questions each of **15 marks**.
  - b. All questions shall be compulsory with internal choice within the questions.

<b>Question</b>	<b>Option</b>	<b>Marks</b>	<b>Based on Units</b>
Q.1	Subjective questions 3 out of 5	15	Unit I
Q.2	Subjective questions 3 out of 5	15	Unit II
Q.3	Subjective questions 3 out of 5	15	Unit III
Q.4	Subjective questions 3 out of 5	15	Unit IV
Q.5	A. True or False (Any Five out of Eight)	05	All Units
	B. Fill in the Blank with correct alternative. (MCQs with Four Options) (Any Five out of Eight)	05	
	C. Match the following (Any Five out of Eight)	05	
<b>Total</b>		<b>75</b>	<b>--</b>

## **Practical**

1. Total Marks for Practical Examination per major component is 50 Marks.
2. Every student shall perform **one experiment** from each Major Component
3. Scheme of Examination:
  - a. Experiment : 40 Marks
  - b. Journal : 05 Marks
  - c. Viva-Voce : 05 Marks
  - Total : 50 Marks**

### **Practical Book/Journal:**

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# University of Mumbai



No. AAMS\_UGS/ICC/2024-25/06

## CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. UG/73 of 2018-19 dated 06<sup>th</sup> July, 2018 relating to the revised syllabus as per the (CBCS) for the Chemistry of T.Y.B.Sc. Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical Chemistry (Sem -V & VI) (3 and 6 units) including Applied Component Drugs and Dyes, Heavy Fine Chemicals and Petrochemicals.

They are hereby informed that the recommendations made by the **Board of Studies in Chemistry** at its meeting held on 11<sup>th</sup> May, 2024 and subsequently passed by the Board of Deans at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.9 (R) have been accepted by the Academic Council at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.9 (R) and that in accordance therewith, the **revised syllabus for T.Y.B.Sc. (Organic Chemistry) – Sem V & VI (CBCS)** has been brought into force with effect from the academic year 2024-25.

(The said circular is available on the University's website [www.mu.ac.in](http://www.mu.ac.in)).

MUMBAI – 400 032  
25<sup>th</sup> June, 2024

*Baliramh*  
(Prof. (Dr.) Baliram Gaikwad)  
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.9 (R) /24/05/2024

Copy forwarded with Compliments for information to:-

- 1) The Dean, Faculty of Science & Technology,
- 2) The Chairman, Board of Studies **Chemistry**,
- 3) The Director, Board of Examinations and Evaluation,
- 4) The Director, Board of Students Development,
- 5) The Director, Department of Information & Communication Technology,
- 6) The Co-ordinator, MKCL,
- 7) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),
- 8) The Deputy Registrar, Result Unit,
- 9) The Deputy Registrar, College Affiliations Development Department (CAD)

**Copy to :-**

- 1. The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
- 2. The Deputy Registrar, College Affiliations & Development Department (CAD),**
- 3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
- 4. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
- 5. The Deputy Registrar, Executive Authorities Section (EA),**
- 6. The Deputy Registrar, PRO, Fort, (Publication Section),**
- 7. The Deputy Registrar, (Special Cell),**
- 8. The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
- 9. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

**They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.**

- 1. P.A to Hon'ble Vice-Chancellor,**
- 2. P.A Pro-Vice-Chancellor,**
- 3. P.A to Registrar,**
- 4. All Deans of all Faculties,**
- 5. P.A to Finance & Account Officers, (F.& A.O),**
- 6. P.A to Director, Board of Examinations and Evaluation,**
- 7. P.A to Director, Innovation, Incubation and Linkages,**
- 8. P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
- 9. The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
- 10. The Director of Board of Student Development,**
- 11. The Director, Department of Students Welfare (DSD),**
- 12. All Deputy Registrar, Examination House,**
- 13. The Deputy Registrars, Finance & Accounts Section,**
- 14. The Assistant Registrar, Administrative sub-Campus Thane,**
- 15. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
- 16. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
- 17. The Assistant Registrar, Constituent Colleges Unit,**
- 18. BUCTU,**
- 19. The Receptionist,**
- 20. The Telephone Operator,**
- 21. The Secretary MUASA**

**for information.**

# University of Mumbai



**Revised Syllabus for**

**T.Y.B.Sc. (Organic Chemistry)**

**Semester – (Sem V and VI)**

**(Choice Based Credit System)**

**(With effect from the academic year 2024-25)**

# University of Mumbai



## Syllabus for Approval

O: _____	<b>Title of Course</b>	T.Y.B.Sc. (Organic Chemistry)
O: _____	<b>Eligibility</b>	As per University Ordinance
R: _____	<b>Passing Marks</b>	40%
<b>No. of years/Semesters:</b>		Three
<b>Level:</b>		UG
<b>Pattern:</b>		Semester
<b>Status:</b>		Revised
<b>To be implemented from Academic Year :</b>		From Academic Year: 2024-25

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# Preamble

## 1) **Introduction**

The B.Sc (Chemistry) program is meticulously structured to foster a deep understanding of chemical principles and their real-world applications. The curriculum is a blend of theoretical knowledge and hands-on experience, ensuring that students not only grasp the core concepts but also develop a passion for the subject. With a focus on continuous assessment through quizzes, class tests, and assignments, the program emphasizes the importance of a strong conceptual foundation. This approach is complemented by practical experiments, where theoretical knowledge is applied, enhancing the learning experience and preparing students to tackle the multifaceted challenges in the field of chemistry.

## 2) **Aims and Objectives**

The B.Sc (Chemistry) program is structured to equip students with a comprehensive understanding of chemical principles and their real-world applications. It aims to foster a deep appreciation for the subject, encouraging students to engage in critical thinking and problem-solving. By integrating theoretical knowledge with practical skills, the course prepares graduates for diverse careers in research, industry, education, and beyond, contributing to their holistic academic and professional growth.

## 3) **Learning Outcomes**

A strong foundation in the fundamental principles of Physical, Inorganic, organic, and Analytical chemistry is essential for a successful career in the sciences. Continuous learning and self-improvement are critical for staying current in the ever-evolving field of chemistry. A curiosity-driven approach to scientific inquiry fosters innovation and discovery. Identifying potential career paths in chemistry-related fields opens up a world of opportunities in diverse industries. Applying acquired skills to entry-level positions can lead to significant advancements in sectors like pharmaceuticals, materials science, and environmental science.

## 4) **Any other point (if any)**

The program is meticulously designed to lay a solid foundation in the subject, equipping students with essential skills and knowledge. Through a blend of theoretical understanding and practical application, the curriculum aims to fortify the students' grasp of the basics, ensuring they are well-prepared for advanced study or professional application in the field. This foundational strength is crucial for their academic and career progression, providing a robust platform from which they can build expertise and specialization.

# T.Y.B.Sc. CHEMISTRY (6 UNITS)

## Choice Based Credit System

To be implemented from the Academic year 2024-25

### Organic Chemistry

#### SEMESTER V

Course Code: USCH503	Credits: 02	Lectures: 60
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Unit	Topic	No. of Lectures	Total No. of Lectures
I	<p><b>1.1 Mechanism of Organic Reactions</b></p> <p><b>1.1.1 The basic terms &amp; concepts:</b> Electrophilicity vs. acidity &amp; nucleophilicity vs basicity.</p> <p><b>1.1.2 Neighbouring group participation in nucleophilic substitution reactions:</b> Participation of lone pair of electrons, kinetics and stereochemical outcome.</p> <p><b>1.1.3 Acyl nucleophilic substitution (Tetrahedral mechanism):</b> Acid catalyzed esterification of carboxylic acids (AAC<sup>2</sup>) and base promoted hydrolysis of esters (BAC<sup>2</sup>).</p> <p><b>1.1.4 Pericyclic reactions, classification and nomenclature.</b></p> <p>1.1.4.1 Electrocyclic reactions (ring opening and ring closing), conrotatory and disrotatory process. Woodward Hoffman rule. Cycloaddition, sigma tropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type)</p> <p>1.1.4.2 Pyrolytic elimination: Cope, Chugaev,</p>	(10L)	15

pyrolysis of acetates.

**Reference Books:**

1. A guidebook to mechanism in Organic Chemistry (Sixth edition), Peter Sykes, Pearson education, New Delhi.
2. Organic Reaction Mechanism (Fourth edition), V. K. Ahluwalia, R. K. Parashar, Narosa Publication.
3. Organic Reactions and their Mechanisms (Third revised edition), P. S. Kalsi, New Age International Publishers.
4. Advanced Organic Chemistry- Reactions Mechanism and Structure (Seventh edition), J. March and M. B. Smith, Wiley Student Edition.

**1.2 Photochemistry**

**1.2.1 Introduction:**

Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization.

**1.2.2 Photochemical reactions of olefins:**

Photoisomerization, photochemical rearrangement of 1,4- dienes (di-  $\pi$  methane).

**1.2.3 Photochemistry of carbonyl compounds:**

Norrish I, Norrish II cleavages. Photo reduction (e.g. benzophenone to benzpinacol).

**Reference Books:**

1. Organic Chemistry (Seventh Edition), R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
2. Organic Chemistry (Eighth edition), John Mc Murry.

(5L)

II

**2.1 Stereochemistry I**

**2.1.1: Molecular chirality and elements of symmetry:**

Mirror plane symmetry, inversion center, rotation - reflection (alternating) axis

**2.1.2: Chirality of compounds without a stereogenic center:**

Cummulenes and Biphenyls.

5L

15

	<p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata McGraw Hill.</li> <li>2. Stereochemistry Conformation and Mechanism (Eleventh Edition), P. S. Kalsi, New Age International Publishers.</li> <li>3. Stereochemistry of Organic Compounds: Principles and Applications (Fourth Edition), D. Nasipuri, New Age International Publishers.</li> </ol>		
	<p><b>2.2 Agrochemicals</b></p> <p><b>2.2.1: General introduction &amp; scope,</b> meaning &amp; examples of insecticides, herbicides, fungicide, rodenticide, pesticides, plant growth regulators</p> <p><b>2.2.2: Advantages &amp; disadvantages of agrochemicals</b></p> <p><b>2.2.3: Synthesis &amp; application of:</b> IAA (Indole Acetic Acid) &amp; Endosulphan, Bio pesticides – Neem oil &amp; Karanj oil.</p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Insecticides &amp; pesticides: Saxena A. B., Anmol publication.</li> <li>2. Growth regulators in Agriculture &amp; Horticulture: Amarjit Basra, CRC press 2000.</li> <li>3. Agrochemicals and Pesticides: A. Jadhav and T.V. Sathe</li> </ol>	4L	
	<p><b>2.3 Heterocyclic Chemistry:</b></p> <p><b>2.3.1:</b> Reactivity of pyridine-N-oxide, quinoline and isoquinoline.</p> <p><b>2.3.2:</b> Preparation of pyridine-N-oxide, quinoline (Skraup synthesis) and iso-quinoline (Bischler- Napieralski synthesis).</p> <p><b>2.3.3:</b> Reactions of pyridine-N-oxide: halogenation, nitration and reaction with <math>\text{NaNH}_2/\text{liq.NH}_3</math>, n-BuLi.</p>	6L	

	<p><b>2.3.4:</b> Reactions of quinoline and isoquinoline; oxidation, reduction, nitration, halogenation and reaction with <math>\text{NaNH}_2/\text{liq. NH}_3</math>, <math>n\text{-BuLi}</math>.</p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Name Reactions in Heterocyclic Chemistry, Jie-Jack Li, Wiley-Interscience publications, 2005.</li> <li>2. Handbook of Heterocyclic Chemistry (Second Edition), Alan R. Katritzky and Alexander F. Pozharskii, Elsevier Science Ltd, 2000.</li> <li>3. Heterocyclic Chemistry (Fifth Edition), John A. Joule and Keith Mills, Wiley publication, 2010.</li> <li>4. Heterocyclic Chemistry (Third Edition), Thomas L. Gilchrist, Pearson Education, 2007.</li> </ol>		
III	<p><b>3.1 IUPAC</b> IUPAC Systematic nomenclature of the following classes of compounds (including compounds up to two substituents / functional groups):</p> <p><b>3.1.1 Bicyclic compounds</b> – spiro, fused and bridged (up to 11 carbon atoms) – saturated and unsaturated compounds.</p> <p><b>3.1.2 Biphenyls</b></p> <p><b>3.1.3 Cummulenes with up to 3 double bonds</b></p> <p><b>3.1.4 Quinolines and Isoquinolines</b></p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Nomenclature of Organic Chemistry: IUPAC recommendations and preferred Names 2013, Henri A. Favre and Warren H. Powell- RSC publication.</li> <li>2. IUPAC nomenclature (Second Edition), S. C. Pal, Narosa Publishing House pvt. Ltd.</li> </ol>	5	15
	<p><b>3.2 Synthesis of Organic Compounds</b></p> <p><b>3.2.1 Introduction:</b> Linear and convergent synthesis, criteria for an ideal synthesis, the concept of chemoselectivity and regioselectivity with examples, and calculation of yields.</p> <p><b>3.2.2 Multicomponent Synthesis:</b> Mannich reaction and Biginelli reaction. Synthesis</p>	10	

		with examples (no mechanism)		
		<p><b>3.2.3 Green Chemistry and Synthesis:</b> Introduction: Twelve principles of Green Chemistry, concept of Atom Economy and E-factor, calculations and their significance, numerical examples. i) Green reagents: dimethyl carbonate ii) Green starting materials: D-glucose iii) Green solvents: supercritical CO<sub>2</sub> iv) Green catalysts: Biocatalysts</p>		
		<p><b>3.2.4 Some Green Methods of Organic Synthesis:</b> Microwave-assisted Organic Synthesis (Using organic solvents and in solid state). Ultrasound in Organic Synthesis, Phase transfer catalysis.</p>		
		<p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Green Chemistry an introductory text (Third Edition), Mike Lancaster, RSC Publication.</li> <li>2. Green Chemistry, V. K. Ahluwalia, Narosa Publishing House pvt. ltd.</li> <li>3. New trends in Green Chemistry, V. K. Ahluwalia, M. Kidwai, Klumer Academic publisher.</li> <li>4. An Introduction to Green Chemistry, V. Kumar, Vishal Publishing Co.</li> <li>5. Organic Chemistry (Tenth Edition), Francis Carey, Tata Mc Graw Hill.</li> <li>6. Organic Chemistry (Fifth edition), Carey and Sundberg, Springer.</li> </ol>		
IV		<b>4.1 Spectroscopy I</b>	7	15
		<p><b>4.1.1 Introduction:</b> Electromagnetic spectrum, units of wavelength and frequency.</p> <p><b>4.1.2 UV – Visible spectroscopy:</b> Basic theory, solvents, nature of UV-Visible spectrum, concept of chromophore, auxochrome, bathochromic and hypsochromic shifts, hyperchromic and hypochromic effects, chromophore-chromophore and chromophore-auxochrome interactions.</p>		

	<p><b>4.1.3 Mass spectrometry:</b></p> <p>Basic theory; Nature of mass spectrum; Importance of molecular ion peak, isotopic peaks, base peak, nitrogen rule, rule of 13 for determination of empirical formula and molecular formula; General rules of fragmentation. Fragmentation of alkanes and aliphatic carbonyl compounds.</p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Organic Spectroscopy (Second edition), J. Mohan, Narosa Publication.</li> <li>2. Introduction to Spectroscopy (Fifth edition), D. L. Pavia, G. M. Lampman, G. S. Kriz, J. A. Vyvyan, Cengage Learning Publication.</li> <li>3. Elementary Organic Spectroscopy (Third edition), Y. R. Sharma, S. Chand Publication.</li> <li>4. Organic Chemistry (Eighth edition), P. Y. Bruice, Pearson education.</li> <li>5. Spectrometric Identification of Organic Compounds (Fifth edition), R.M. Silverstein, Wiley publication.</li> </ol>		
2)	<p><b>4.2. Natural Products</b></p> <p><b>4.2.1 Introduction and broad classification of Natural products based on Chemical structure and physiological activity.</b></p> <p><b>4.2.2 Terpenoids</b></p> <ol style="list-style-type: none"> <li>a) Introduction</li> <li>b) Isoprene rule, special isoprene rule and the gem-dialkyl rule.</li> </ol> <p><b>4.2.3 Citral</b></p> <ol style="list-style-type: none"> <li>a) Structural determination of citral.</li> <li>b) Synthesis of citral from methyl heptanone.</li> <li>c) Isomerism in citral (cis and trans forms).</li> </ol> <p><b>4.2.3 Alkaloids</b></p> <ol style="list-style-type: none"> <li>a) Introduction and occurrence.</li> <li>b) Hofmann's exhaustive methylation and degradation in: simple open chain and N – substituted monocyclic amines.</li> </ol> <p><b>4.2.5 Nicotine</b></p> <ol style="list-style-type: none"> <li>a) Structural determination of nicotine. (Pinner's work included).</li> <li>b) Synthesis of nicotine from nicotinic acid.</li> <li>c) Harmful effects of nicotine.</li> </ol> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Organic Chemistry of Natural Products, Vol I and</li> </ol>	8	

		<p>Vol II (First edition), A. Chatwal, Himalaya Publishing House.</p> <p>2. Organic Chemistry Natural Products, Vol I and Vol II (First edition), O. P. Agarwal, Krishna Publications.</p> <p>3. Chemistry of Natural Products (First edition), S. V. Bhat, B. A. Nagasampagi, M. Sivakumar, Springer Narosa Publication.</p> <p>4. Organic Chemistry (Seventh edition), R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Pearson Education.</p> <p>5. Organic Chemistry, Vol II, (Fifth edition), I. L. Finar, Pearson Education.</p> <p>6. Natural Products Chemistry (First edition), K. Nakanishi, T. Goto, Academic Press.</p>		
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## SEMESTER V PRACTICALS

<b>Course Code: USCHP09</b>	<b>Credits: 02</b>
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### **A) Separation of Binary solid-solid mixture (2.0 gms mixture to be given).**

1. Minimum Six mixtures to be completed by the students.
2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (2-naphthol, 1-naphthol), water insoluble base (nitroanilines), water soluble neutral (thiourea) and water insoluble neutral compounds (anilides, amides, m-DNB, hydrocarbons).
3. After correct determination of chemical type, the separating reagent should be decided by the student for separation.
4. Follow separation scheme with the bulk sample of binary mixture.
5. After separation into component A and component B, one component (decided by the examiner) is to be analyzed and identified with m.p.

### **Reference Books:**

1. Practical Organic Chemistry – A. I. Vogel
2. Practical Organic Chemistry – H. Middleton
3. Practical Organic Chemistry – O. P. Agarwal

# Organic Chemistry

## SEMESTER VI

Course Code: USCH603	Credits: 02	Lectures: 60
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Unit	Topic	No. of Lectures
Unit I	<b>1.1 Stereochemistry II</b>	10L
	<b>1.1.1 Stereoselectivity and stereospecificity:</b> Idea of enantioselectivity (ee) and diastereoselectivity (de), Topicity: enantiotopic and diastereotopic atoms, groups and faces.  <b>1.1.2 Stereochemistry of –</b> i) Substitution reactions: S <sub>N</sub> i (reaction of alcohol with thionyl chloride) ii) Elimination reactions: E <sub>2</sub> -Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane. iii) Addition reactions to olefins: a) Bromination (electrophilic anti addition) b) Syn hydroxylation with OsO <sub>4</sub> and KMnO <sub>4</sub> c) Epoxidation followed by hydrolysis  <b>Reference Books:</b>  1. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata McGraw Hill. 2. Stereochemistry Conformation and Mechanism (Eleventh Edition), P. S. Kalsi, New Age International. 3. Stereochemistry of Organic Compounds: Principles and Applications (Fourth Edition), D. Nasipuri, New Age International.	
	<b>1.2 Amino acids &amp; Proteins</b>	5L
	<b>1.2.1 <math>\alpha</math>-Amino acids:</b> General Structure, configuration, and classification based on structure and nutrition. Properties: pH dependency of ionic structure, isoelectric point and zwitter ion. Methods of preparations: Strecker synthesis, Gabriel phthalamide synthesis.  <b>1.2.2 Polypeptides and Proteins:</b> Nature of peptide bond. Nomenclature and representation of polypeptides (di- and tri-peptides) with examples, Merrifield solid phase polypeptide synthesis. Proteins: General idea of primary, secondary, tertiary & quaternary structure  <b>Reference Books:</b>  1. Biochemistry (Eighth Edition), J. M. Berg, J. L. Tymoczko, G. J. Gatto, Jr. L. Stryer, W.H. Freeman Publication.	

	<p>2. Principles of Biochemistry (Seventh Edition), D. L. Nelson and M. M. Cox, Lehninger, W. H. Freeman Publication.</p> <p>3. Name Reactions (Fourth Edition), J. J. Li, Springer Publication.</p>	
<b>Unit II</b>	<p><b>2.1 Molecular Rearrangements</b></p> <p><b>Mechanism of the following rearrangements with examples and stereochemistry wherever applicable.</b></p> <p><b>2.1.1 Migration to the electron deficient carbon:</b> Pinacol-pinacolone rearrangement.</p> <p><b>2.1.2 Migration to the electron deficient nitrogen:</b> Beckmann rearrangement.</p> <p><b>2.1.3 Migration involving a carbanion:</b> Favorskii rearrangement.</p> <p><b>2.1.4 Name reactions:</b> Michael addition, Wittig reaction.</p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. A guidebook to mechanism in Organic Chemistry (Sixth edition), Peter Sykes, Pearson education, New Delhi</li> <li>2. Organic Reaction Mechanism (Fourth edition), V. K. Ahluwalia, R. K. Parashar, Narosa Publication.</li> <li>3. Organic Reactions and their mechanisms (Third revised edition), P. S. Kalsi, New Age International Publishers.</li> <li>4. Advanced Organic Chemistry- Reactions, Mechanism and Structure (Seventh edition), J. March and M. B. Smith, Wiley Student Edition.</li> </ol>	<b>5L</b>
	<p><b>2.2 Carbohydrates</b></p> <p><b>2.2.1 Introduction:</b> Classification, reducing and non-reducing sugars, DL notation.</p> <p><b>2.2.2 Structures of monosaccharides:</b> Fischer projection (4-6 carbon monosaccharides) and Haworth formula (furanose and pyranose forms of pentoses and hexoses). Interconversion: open chain and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with stereochemistry of D-glucose, Stability of chair form of D-glucose.</p> <p><b>2.2.3 Stereoisomers of D-glucose:</b> Enantiomer, diastereomers, anomers, epimers.</p> <p><b>2.2.4 Mutarotation in D-glucose with mechanism.</b></p> <p><b>2.2.5 Chain lengthening &amp; shortening reactions:</b> Modified Kiliani-Fischer synthesis (D-arabinose to D-glucose and D-</p>	<b>10L</b>

	<p>mannose), Wohl method (D-glucose to D-arabinose).</p> <p><b>2.2.6 Reactions of D-glucose and D-fructose:</b>  (a) Osazone formation (b) reduction: <math>H_2/Ni</math>, <math>NaBH_4</math> (c) oxidation: bromine water, <math>HNO_3</math>, <math>HIO_4</math> (d) acetylation (e) methylation (d) and (e) with cyclic pyranose forms.</p> <p><b>2.2.7 Glycosides: general structure.</b></p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Organic Chemistry (Fourth edition), G. Marc Loudon, Oxford University press.</li> <li>2. Introduction to Organic Chemistry (Fourth edition), Andrew Streitwieser, Jr. Clayton H. Heathcock, Macmillan publishing, New York.</li> <li>3. Organic Chemistry (Sixth edition), Morrison and Boyd, Pearson Education.</li> <li>4. Introduction to Organic Chemistry, John Mc Murry, Cengage Publisher.</li> <li>5. Organic Chemistry, Volume- 1 &amp; 2 (Fifth and sixth edition), I. L. Finar, Pearson Education.</li> </ol>	
<p><b>Unit III</b></p>	<p><b>3.1 Spectroscopy II</b></p> <p><b>3.1.1 IR spectroscopy:</b>  Basic Theory, Nature of IR spectrum, selection rule, finger print region.</p> <p><b>3.1.2 <math>^1H</math>-NMR spectroscopy:</b>  Basic theory of <math>^1H</math>-NMR, nature of <math>^1H</math>-NMR spectrum, chemical shift (<math>\delta</math> unit), standard for <math>^1H</math>-NMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to <math>C=C</math>, <math>C\equiv C</math>, <math>C=O</math> and benzene ring). Spin- spin coupling and coupling constant. application of deuterium exchange technique. application of <math>^1H</math>-NMR in structure determination.</p> <p><b>3.1.3 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to IR and <math>^1H</math>-NMR:</b>  (1) alkanes (2) alkenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) amines (broad regions characteristic of different groups are expected).  Problems of structure elucidation of simple organic compounds using individual or combined use of UV-Vis, IR, Mass and <math>^1H</math>-NMR spectroscopic technique are expected. (Index of hydrogen deficiency should be the first step in solving the problems).</p> <p><b>Reference Books:</b></p>	<p><b>10L</b></p>

	<ol style="list-style-type: none"> <li>1. Organic Spectroscopy (Second edition), Jag Mohan, Narosa publication.</li> <li>2. Introduction to Spectroscopy (Fifth edition), D. L. Pavia, G. M. Lampman, G. A. Kriz, J. R. Vyvyan, Cengage Learning.</li> <li>3. Elementary Organic Spectroscopy (Third edition), Y. R. Sharma, S. Chand publication.</li> <li>4. Organic Chemistry, Paula Y. Bruice, Pearson education.</li> <li>5. Spectrometric Identification of Organic Compounds (Paperback – Illustrated, 29 Sept. 2014 English edition), <u>Robert M. Silverstein</u>, <u>Francis X. Webster</u>, <u>David J. Kiemle</u>, <u>David L. Bryce</u>, Wiley.</li> <li>6. Absorption Spectroscopy of Organic Molecules, V. M. Parikh, Addison Wesley Publishing Company.</li> </ol>	
	<p><b>3.2 Nucleic Acids</b> Controlled hydrolysis of nucleic acids. sugars and bases in nucleic acids. Structures of nucleosides and nucleotides in DNA and RNA. Structures of nucleic acids (DNA and RNA) including base pairing.</p> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Organic Chemistry (Sixth edition), R. T. Morrison and R. N. Boyd, Pearson education.</li> <li>2. Organic Chemistry (Fourth edition), S. H. Pine, Tata McGraw Hill.</li> </ol>	<b>5L</b>
<b>Unit IV</b>	<p><b>4.1 Polymers:</b></p> <p><b>4.1.1: Introduction:</b> Terms monomer, polymer, homopolymer, copolymer, thermo plastics and thermosets.</p> <p><b>4.1.2: Addition polymers:</b> Polyethylene, polypropylene, teflon, polystyrene, PVC, Uses.</p> <p><b>4.1.3: Condensation polymers:</b> Polyesters, polyamides, polyurethanes, polycarbonates, phenol formaldehyde resins and uses of each one of these.</p> <p><b>4.1.4: Stereochemistry of polymers:</b> Tacticity, mechanism of stereochemical control of polymerization using Ziegler Natta catalysts</p> <p><b>4.1.5: Natural and synthetic rubbers:</b> Polymerisation of isoprene: 1,2 and 1,4 addition (cis and trans), Styrene butadiene copolymer.</p> <p><b>4.1.6: Additives to polymers:</b> Plasticisers, stabilizers and fillers.</p>	<b>8L</b>

**4.1.7: Biodegradable polymers:**

Classification and uses. polylactic acid structure, properties and use for packaging and medical purposes.

(Note: Identification of monomer in a given polymer & structure of polymer for a given monomer is expected. condition for polymerization is not expected)

**Reference Books:**

1. Polymer Chemistry, M. G. Arora, K. Singh, Anmol Publications Pvt. Ltd.
2. Polymer Science, V. K. Ahluwalia and A. Mishra, Ane books.
3. Polymer Chemistry An Introduction, v.12, (Third edition), R. B. Seymour, C.E. Carraher, Marcel Dekker.

**4.2 Catalysts and Reagents:**

Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism)

**7L****4.2.1: Catalysts: Catalysts for hydrogenation:**

- a. Raney Nickel
- b. Pt and PtO<sub>2</sub> (C=C, CN, NO<sub>2</sub>, aromatic ring)
- c. Pd/C: C=C, COCl→CHO (Rosenmund)
- d. Lindlar catalyst: alkynes

**4.2.2: Reagents:**

- a. LiAlH<sub>4</sub> (reduction of CO, COOR, CN, NO<sub>2</sub>)
- b. NaBH<sub>4</sub> (reduction of CO)
- c. SeO<sub>2</sub> (Oxidation of CH<sub>2</sub> alpha to CO)
- d. mCPBA (epoxidation of C=C)
- e. NBS (allylic and benzylic bromination)

**Reference Books:**

1. Organic Chemistry (Eighth edition), Francis A. Carey, R. M. Giuliano, McGraw Hill Education.
2. Advanced Organic Chemistry (Part A & B- Fifth edition), Francis A. Carey and Richard J. Sundberg, Springer.

## SEMESTER VI PRACTICALS

Course Code: USCHP10

Credits: 02

### A) Separation of Binary liquid-liquid and liquid- solid mixture.

1. Minimum Six mixtures to be completed by the students.
2. Components of the liquid-liquid mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, isopropyl alcohol, ethyl alcohol, EMK and non-volatile liquids like chlorobenzene, bromobenzene, aniline, N, N- dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate.
3. Components of the liquid - solid mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, ethyl alcohol, IPA, EMK and solids such as water insoluble acids, phenols, bases, neutral.
4. A sample of the mixture one ml to be given to the student for detection of the physical type of the mixture.
5. After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique.
6. After separation into component A and component B, the compound to be identified can be decided by examiner.

### Reference Books:

1. Practical Organic Chemistry – A. I. Vogel
2. Practical Organic Chemistry – H. Middleton
3. Practical Organic Chemistry – O. P. Agarwal

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## Evaluation Pattern for Semesters V and VI

### Semester End Theory Examination

<b>Internal Continuous Assessment: 25% (25 Marks)</b>	<b>Semester End Examination: 75% (75 Marks)</b>	<b>Duration for End Semester Examination</b>
<b>Continuous Evaluation through:</b> Quizzes, Class Tests, Presentations, Projects, Role Plays, Creative Writings, Assignments, etc.	As per following pattern	2 hrs 30 minutes

### Pattern for Semester End Examination (75 Marks):

1. Duration - This examination shall be of **Two hours and 30 minutes** duration.
2. Theory question paper pattern:
  - a. There shall be **05** questions each of **15 marks**.
  - b. All questions shall be compulsory with internal choice within the questions.

Question	Option	Marks	Based on Units
Q.1	Subjective questions 3 out of 5	15	Unit I
Q.2	Subjective questions 3 out of 5	15	Unit II
Q.3	Subjective questions 3 out of 5	15	Unit III
Q.4	Subjective questions 3 out of 5	15	Unit IV
Q.5	A. True or False (Any Five out of Eight)	05	All Units
	B. Fill in the Blank with correct alternative. (MCQs with Four Options) (Any Five out of Eight)	05	
	C. Match the following (Any Five out of Eight)	05	
<b>Total</b>		<b>75</b>	<b>--</b>

## **Practical**

1. Total Marks for Practical Examination per major component is 50 Marks.
2. Every student shall perform **one experiment** from each Major Component
3. Scheme of Examination:
  - a. Experiment : 40 Marks
  - b. Journal : 05 Marks
  - c. Viva-Voce : 05 Marks

**Total : 50 Marks**

## **Practical Book/Journal:**

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**

# University of Mumbai



No. AAMS\_UGS/ICC/2024-25/09

## CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. UG/73 of 2018-19 dated 06<sup>th</sup> July, 2018 relating to the revised syllabus as per the (CBCS) for the Chemistry of T.Y.B.Sc. Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical Chemistry (Sem -V & VI) (3 and 6 units) including Applied Component Drugs and Dyes, Heavy Fine Chemicals and Petrochemicals.

They are hereby informed that the recommendations made by the **Board of Studies in Chemistry** at its meeting held on 11<sup>th</sup> May, 2024 and subsequently passed by the Board of Deans at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.12 (R) have been accepted by the Academic Council at its meeting held on 24<sup>th</sup> May, 2024 vide item No. 6.12 (R) and that in accordance therewith, the **revised syllabus for T.Y.B.Sc. (Analytical Chemistry) – Sem V & VI (CBCS)** has been brought into force with effect from the academic year 2024-25.

(The said circular is available on the University's website [www.mu.ac.in](http://www.mu.ac.in)).

MUMBAI – 400 032  
25<sup>th</sup> June, 2024

*Baliram*  
(Prof. (Dr.) Baliram Gaikwad)  
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.12 (R) /24/05/2024

Copy forwarded with Compliments for information to:-

- 1) The Dean, Faculty of Science & Technology,
- 2) The Chairman, Board of Studies **Chemistry**,
- 3) The Director, Board of Examinations and Evaluation,
- 4) The Director, Board of Students Development,
- 5) The Director, Department of Information & Communication Technology,
- 6) The Co-ordinator, MKCL,
- 7) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),
- 8) The Deputy Registrar, Result Unit,
- 9) The Deputy Registrar, College Affiliations Development Department (CAD)

**Copy to :-**

- 1. The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
- 2. The Deputy Registrar, College Affiliations & Development Department (CAD),**
- 3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
- 4. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
- 5. The Deputy Registrar, Executive Authorities Section (EA),**
- 6. The Deputy Registrar, PRO, Fort, (Publication Section),**
- 7. The Deputy Registrar, (Special Cell),**
- 8. The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
- 9. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

**They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.**

- 1. P.A to Hon'ble Vice-Chancellor,**
- 2. P.A Pro-Vice-Chancellor,**
- 3. P.A to Registrar,**
- 4. All Deans of all Faculties,**
- 5. P.A to Finance & Account Officers, (F.& A.O),**
- 6. P.A to Director, Board of Examinations and Evaluation,**
- 7. P.A to Director, Innovation, Incubation and Linkages,**
- 8. P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
- 9. The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
- 10. The Director of Board of Student Development,**
- 11. The Director, Department of Students Welfare (DSD),**
- 12. All Deputy Registrar, Examination House,**
- 13. The Deputy Registrars, Finance & Accounts Section,**
- 14. The Assistant Registrar, Administrative sub-Campus Thane,**
- 15. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
- 16. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
- 17. The Assistant Registrar, Constituent Colleges Unit,**
- 18. BUCTU,**
- 19. The Receptionist,**
- 20. The Telephone Operator,**
- 21. The Secretary MUASA**

**for information.**

# University of Mumbai



**Revised Syllabus for**  
**T.Y.B.Sc. (Analytical Chemistry)**  
**Semester – (Sem V and VI)**  
**(Choice Based Credit System)**

**(With effect from the academic year 2024-25)**

# University of Mumbai



## Syllabus for Approval

O: _____ Title of Course	T.Y.B.Sc. (Analytical Chemistry)
O: _____ Eligibility	As per University Ordinance
R: _____ Passing Marks	40%
No. of years/Semesters:	Three
Level:	UG
Pattern:	Semester
Status:	Revised
To be implemented from Academic Year :	From Academic Year: 2024-25

Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry

Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology

Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology

# Preamble

## 1) **Introduction**

The B.Sc (Chemistry) program is meticulously structured to foster a deep understanding of chemical principles and their real-world applications. The curriculum is a blend of theoretical knowledge and hands-on experience, ensuring that students not only grasp the core concepts but also develop a passion for the subject. With a focus on continuous assessment through quizzes, class tests, and assignments, the program emphasizes the importance of a strong conceptual foundation. This approach is complemented by practical experiments, where theoretical knowledge is applied, enhancing the learning experience and preparing students to tackle the multifaceted challenges in the field of chemistry.

## 2) **Aims and Objectives**

The B.Sc (Chemistry) program is structured to equip students with a comprehensive understanding of chemical principles and their real-world applications. It aims to foster a deep appreciation for the subject, encouraging students to engage in critical thinking and problem-solving. By integrating theoretical knowledge with practical skills, the course prepares graduates for diverse careers in research, industry, education, and beyond, contributing to their holistic academic and professional growth.

## 3) **Learning Outcomes**

A strong foundation in the fundamental principles of Physical, Inorganic, organic, and Analytical chemistry is essential for a successful career in the sciences. Continuous learning and self-improvement are critical for staying current in the ever-evolving field of chemistry. A curiosity-driven approach to scientific inquiry fosters innovation and discovery. Identifying potential career paths in chemistry-related fields opens up a world of opportunities in diverse industries. Applying acquired skills to entry-level positions can lead to significant advancements in sectors like pharmaceuticals, materials science, and environmental science.

## 4) **Any other point (if any)**

The program is meticulously designed to lay a solid foundation in the subject, equipping students with essential skills and knowledge. Through a blend of theoretical understanding and practical application, the curriculum aims to fortify the students' grasp of the basics, ensuring they are well-prepared for advanced study or professional application in the field. This foundational strength is crucial for their academic and career progression, providing a robust platform from which they can build expertise and specialization.

# T.Y.B.Sc. CHEMISTRY (6 UNITS)

Choice Based Credit System

To be implemented from the Academic year 2024-25

## Paper IV: Analytical Chemistry

SEMESTER V

<b>Course Code: USCH504</b>	<b>Credits: 02</b>	<b>Lectures: 60</b>
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Unit	Topic		No. of Lectures	Total No. of Lectures
I Introduction to quality concepts, chemical calculations, and sampling	1)	Quality in Analytical Chemistry	05	15
	2)	Chemical Calculations	04	
	3)	Sampling	06	
II Classical methods of Analysis	1)	Neutralization Titrations	03	15
	2)	Redox Titrations	04	
	3)	Complexometric Titrations	08	
III Optical Methods	1)	Atomic Spectroscopy: Flame Emission spectroscopy (FES) and Atomic Absorption Spectroscopy(AAS)	07	15
	2)	Molecular Fluorescence and Phosphorescence Spectroscopy	04	
	3)	Turbidimetry and Nephelometry	04	
IV Methods of Separation -I	1)	Solvent Extraction	06	15
	2)	Gas Chromatography	09	

Unit	Topic	No. of Lectures	
	<b>1.1 Quality in Analytical Chemistry</b>	<b>05</b>	
<b>Unit I</b>	1.1.1	Concepts of Quality, Quality Control and Quality Assurance	
	1.1.2	Importance of Quality concepts in Industry	
	1.1.3	Chemical Standards and Certified Reference Materials; Importance in chemical analysis Quality of material: Various grades of laboratory reagents	
		<b>1.2 Chemical Calculations (Numericals and word problems are expected)</b>	<b>04</b>
	1.2.1	Inter conversion of various concentration units. (Conversion of concentration from one unit to another unit with examples)	
	1.2.2	Percent composition of elements in chemical compounds	
	<b>1.3 Sampling</b>	<b>06</b>	
	1.3.1	Sampling of solids: Sample size – bulk ratio, size to weight ratio, multistage and sequential sampling, size reduction methods, sampling of compact solids, equipments and methods of sampling of compact solids, sampling of particulate solids, methods and equipments used for sampling of particulate solids.	
	1.3.2	Sampling of liquids: Homogeneous and heterogeneous, Static and flowing liquids.	
	1.3.3	Sampling of gases: Ambient and stack sampling: Apparatus and methods for sampling of gases.	
	1.3.4	Collection, preservation and dissolution of the sample.	
<b>Unit II</b>	<b>2.1 Neutralization Titrations ( Calculation of pH in the beginning, at equivalence point and after the equivalence point )</b>	<b>03</b>	
	2.1.1	Strong acid vs Strong Base	
	2.1.2	Weak acid vs Strong Base	
		<b>2.2 Redox Titrations (Numerical and word problems are expected)</b>	<b>04</b>
	2.2.1	Introduction	
	2.2.2	Construction of the titration curves and calculation of $E_{\text{system}}$ in aqueous medium in case of One electron system	
	2.2.3	Theory of redox indicators, Criteria for selection of an indicator Use of diphenyl amine and ferroin as redox indicators	
		<b>2.3 Complexometric Titrations</b>	<b>08</b>
	2.3.1	Introduction, construction of titration curve	
	2.3.2	Use of EDTA as titrant and its standardisation, absolute and conditional formation constants of metal EDTA complexes, Selectivity of EDTA as a titrant. Factors enhancing selectivity of EDTA as a titrant with examples. Advantages and limitations of EDTA as a titrant.	
2.3.3	Types of EDTA titrations.		
2.3.4	Metallochromic indicators, theory, examples and applications		
<b>UNIT III:</b>	<b>3.1 Atomic Spectroscopy: Flame Emission spectroscopy(FES) and Atomic Absorption Spectroscopy(AAS)</b>	<b>07</b>	

	3.1.1	Introduction, Absorption and Emission Spectra	
	3.1.2	Flame Photometry – Principle, Instrumentation (Flame atomizers, types of Burners, Wavelength selectors, Detectors)	
	3.1.3	Atomic Absorption Spectroscopy – Principle, Instrumentation (Source, Chopper, Flame and Electrothermal Atomiser)	
	3.1.4	Qualitative and Quantitative analysis with respect to FES and AAS – Calibration curve method, Standard addition method and Internal standard method.	
	3.1.5	Comparison between FES and AAS	
	3.1.6	Applications, Advantages and Limitations	
	<b>3.2 Molecular Fluorescence and Phosphorescence Spectroscopy</b>		<b>04</b>
	3.2.1	Introduction and Principle	
	3.2.2	Relationship of Fluorescence intensity with concentration	
	3.2.3	Factors affecting Fluorescence and Phosphorescence	
	3.2.4	Instrumentation and applications	
	3.2.5	Comparison of Fluorimetry and Phosphorimetry	
	3.2.6	Comparison with Absorption methods	
	<b>3.3 Turbidimetry and Nephelometry</b>		<b>04</b>
	3.3.1	Introduction and Principle	
	3.3.2	Factors affecting scattering of Radiation: Concentration, particle size, wavelength and refractive index	
	3.3.3	Instrumentation and Applications	
<b>Unit IV</b>	<b>4.1 Solvent Extraction</b>		<b>06</b>
	4.1.1	Factors affecting extraction: Role of complexing agents in solvent extraction Chelation, Ion pair formation and Solvation	
	4.1.2	Graph of percent extraction versus pH. Concept of $[pH]_{1/2}$ and its significance (derivation not expected)	
	4.1.3	Craig's counter current extraction: Principle, apparatus and applications	
	4.1.4	Solid phase extraction: Principle, process and applications with special reference to water and industrial effluent analysis.	
	4.1.5	Comparison of solid phase extraction and solvent extraction.	
	<b>4.2 Gas Chromatography (Numerical and word problems are expected)</b>		<b>09</b>
	4.2.1	Introduction, Principle, Theory and terms involved	
	4.2.2	Instrumentation: Block diagram and components, types of columns, stationary phases in GSC and GLC, Detectors: TCD, FID, ECD	
	4.2.3	Qualitative, Quantitative analysis and applications	
	4.2.4	Comparison between GSC and GLC	

**Reference Books:**

1.	3000 solved problems in Chemistry, David E. Goldberg,PhD.,Schaums Outline	Unit/s: (1.2)
2.	A guide to Quality in Analytical Chemistry: An aid to accreditation, CITAC and EURACHEM, (2002),	Unit/s (1.1)
3.	A premier sampling solids, liquids and gases, Smith Patricia I, American statistical association and the society for industrial and applied mathematics, (2001)	Unit/s (1.3)
4.	Analytical Chemistry, Gary.D Christan, 5th edition	Unit/s (4.1,4.2,4.3)
5.	Analytical Chemistry, Skoog, West ,Holler,7th Edition	Unit/s (2.1, 2.2 2.3)
6.	Analytical Chromatography, Gurdeep R Chatwal, Himalaya publication	Unit/s (4.1,4.2)
7.	Basic Concepts of Analytical Chemistry, by S M Khopkar, new Age International (p) Limited	Unit/s (4.1,4.2)
8.	Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969	Unit/s (4.1,4.2)
9.	Fundamentals of Analytical Chemistry by Skoog and West , 8th Edition	Unit/s (4.1,4.2)
10.	Handbook of quality assurance for the analytical chemistry laboratory, 2ndEdn., James P. DuxVanNostr and Reinhold, 1990	Unit/s (1.1)
11.	Instrumental methods of Analysis, by Dr Supriya S Mahajan, Popular Prakashan Ltd	Unit/s (4.1,4.2)
12.	Instrumental methods Of Analysis, by Willard Merritt Dean, 7thEdition, CBS Publisher and distribution Pvt Ltd	Unit/s (3.1,3.2,3.3)
13.	Instrumental Methods of Chemical Analysis by B.K. Sharma Goel Publishing House	Unit/s (4.1,4.2)
14.	Principles of Instrumental Analysis , 5th Edition, By Skoog, Holler, Nieman	Unit/s (4.1,4.2) (3.1,3.2,3.3)
15.	Quality control and Quality assurance in Analytical Chemical Laboratory, Piotr Konieczka and Jacek Namiesnik, CRC press (2018)	Unit/s (1.1)
16.	Quality in the Analytical Chemistry Laboratory, Elizabeth Prichard, Neil T. Crosby, Florence Elizabeth Prichard, John Wiley and Sons, 1995	Unit/s (1.1)
17.	Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969	Unit/s (4.1,4.2)

## PRACTICALS

Course Code: USCHP504

Credits: 02

### Non-Instrumental Experiments

1. To determine the amount of persulphate in the given sample solution by back titration with standard Fe (II) ammonium sulphate solution.
2. To determine the amount of Iron present in iron sample by redox titration using potassium dichromate with diphenyl amine as an indicator.
3. To estimate amount of Calcium from given sample by complexometric titration.

### Instrumental Experiments

1. To determine potassium content of a Fertilizer by Flame Photometry (Calibration curve Method)
2. To determine the amount of sulphate in given water sample turbidimetrically.
3. Estimation of Chromium in water sample spectrophotometrically by using Diphenyl Carbazide.

### Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn., G. H. Jeffery, J Bassett, J Mendham and R C Denney, ELBS with Longmann (1989).

2. Vogel's Textbook of Quantitative Chemical analysis, Sixth edition, J. Mendham et al

# T.Y.B.Sc. CHEMISTRY (6 UNITS)

Choice Based Credit System

To be implemented from the Academic year 2024-25

## Paper IV: Analytical Chemistry

SEMESTER VI

<b>Course Code: USCH604</b>	<b>Credits: 02</b>	<b>Lectures: 60</b>
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Unit	Topic		No. of Lectures	Total No. of Lectures
I Electroanalytical Techniques	1)	Polarography	11	15
	2)	Amperometric Titrations	04	
II Methods of Separation - II	1)	High Performance Liquid chromatography (HPLC)	06	15
	2)	High Performance Thin Layer Chromatography (HPTLC)	03	
	3)	Ion Exchange Chromatography	06	
III Food and Cosmetics Analysis	1)	Introduction to food chemistry	10	15
	2)	Cosmetics	05	
IV Thermal and Radioanalytical Methods	1)	Thermal Methods	12	15
	2)	Radio Analytical Methods	03	

Unit	Topic	No. of Lectures	
<b>Unit I</b>	<b>1.1 Polarography (Numerical and word problems are expected)</b>	<b>11</b>	
	1.1.1		Difference between potentiometry and voltammetry, Polarizable and non-polarizable electrodes.
	1.1.2		Basic principle of polarography H-shaped polarographic cell, DME (construction, working, advantages and limitations)
	1.1.3		DC polarogram: Terms involved - Residual current, Diffusion current, Limiting current, Half-Wave Potential Role and selection of supporting electrolyte, Interference of oxygen and its removal, polarographic maxima and Maxima Suppressors Qualitative aspects of Polarography: Half wave potential $E_{1/2}$ , Factors affecting $E_{1/2}$ Quantitative aspects of polarography: Ilkovic equations: various terms involved in it (No derivation)
	1.1.4		Quantification 1) Wave height – Concentration plots (working plots/calibration) 2) Internal standard (pilot ion) method 3) Standard addition method
	1.1.5		Applications, advantages and limitations
	<b>1.2 Amperometric Titrations</b>	<b>04</b>	
1.2.1	Principle, Rotating Platinum Electrode(Construction, advantages and limitations)		
1.2.2	Titration curves with example		
1.2.3	Advantages and limitations		
<b>Unit II</b>	<b>2.1 High Performance Liquid chromatography (HPLC)</b>	<b>06</b>	
	2.1.1		Introduction and Principle Instrumentation- components with their significance: Solvent Reservoir, Degassing system, Pumps-(reciprocating pumps, screw driven- syringe type pumps, pneumatic pumps, advantages and disadvantages of each pump), Precolumn, Sample injection system, HPLC Columns, Detectors(UV – Visible detector, Refractive index detector)
	2.1.2	Qualitative and Quantitative Applications of HPLC	
		<b>2.2 High Performance Thin Layer Chromatography (HPTLC)</b>	<b>03</b>
	2.2.1	Introduction and Principle Stationary phase, Sample application and mobile phase	
	2.2.2	Detectors a) Scanning densitometer- Components. Types of densitometer- Single beam and Double beam Fluorometric Detector	
	2.2.3	Advantages, disadvantages, and applications	
	2.2.4	Comparison of TLC and HPTLC	

	<b>2.3 Ion Exchange Chromatography</b>	<b>06</b>
	2.3.1 Introduction, Principle	
	2.3.2 Types of Ion Exchangers , Ideal properties of resin	
	2.3.3 Ion Exchange equilibria and mechanism, selectivity coefficient and separation factor Factors affecting separation of ions.	
	2.3.4 Ion exchange capacity and its determination for cation and anion exchangers.	
<b>Unit III</b>	<b>3.1 Introduction to food chemistry</b>	<b>10</b>
	3.1.1 Food processing and preservation: Introduction, need, chemical methods, action of chemicals (sulphur dioxide, boric acid, sodium benzoate, acetic acid, sodium chloride and sugar) and pH control Physical methods (Pasteurization and Irradiation)	
	3.1.2 Determination of boric acid by titrimetry.	
	3.1.3 Study and analysis of food products and detection of adulterants <b>1) Milk:</b> Composition & nutrients, types of milk (fat free, organic and lactose milk) Analysis of milk for lactose by Lane Eynon's Method	
	<b>2) Honey:</b> Composition, Analysis of reducing sugars in honey by Wilstater's method <b>3) Tea:</b> Composition, types (green tea and mixed tea) Analysis of Tannin by Lowenthal's method. <b>4) Coffee:</b> Constituents and composition, Role of Chicory .	
	<b>3.2 Cosmetics</b>	<b>05</b>
	3.2.1 Introduction and sensory properties	
	3.2.2 Study of cosmetic products – <b>1) Face powder:</b> Composition, Estimation of calcium and Magnesium in Face powder by complexometric titration <b>2) Lipstick:</b> Constituents, Ash analysis for water soluble salts: borates, carbonates and zinc oxide. <b>3) Deodorants and Antiperspirants:</b> Constituents, properties, Estimation of zinc by gravimetry.	
<b>UNIT IV</b>	<b>4.1 Thermal Methods</b>	<b>12</b>
	4.1.1 Introduction to various thermal methods (TGA, DTA and Thermometric titration)	
	4.1.2 <b>Thermogravimetric Analysis(TGA)</b> Instrumentation-block diagram, thermobalance (Basic components: balance, furnace, temperature measurement and control, recorder) Thermogram (TG curve)for $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ Factors affecting thermogram-Instrumental factors and Sample characteristics. Applications: Determination of drying and ignition temperature range, Determination of percent composition of binary mixtures (Estimation of Calcium and Magnesium oxalate)	
	4.1.3 <b>Differential Thermal Analysis (DTA):</b> Principle, Instrumentation and types of reference materials used	

	Differential thermogram ( DTA curve) $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , Applications of DTA	
	Comparison between TGA and DTA.	
4.1.4	<b>Thermometric Titrations</b> – Principle and Instrumentation Thermometric titrations of : 1) HCl v/s NaOH 2) Mixture of $\text{Ca}^{+2}$ and $\text{Mg}^{+2}$ v/s EDTA 3) Boric acid v/s NaOH .	
<b>4.2 Radio Analytical Methods</b>		<b>03</b>
4.2.1	Introduction, Classification of Radio analytical methods	
4.2.2	Neutron activation analysis (NAA) :Principle and theory Advantages, limitations and applications of NAA	

## REFERENCES

1.	An Advance Dairy chemistry, V 3, P. F. Fox, P. L. H. McSweeney Springer	Unit/s (3.1,3.2)
2.	Analysis of food and Beverages, George Charalanbous, Academic press 1978	Unit/s (3.1,3.2)
3.	Analytical Chemistry of Open Learning(ACOL),James W. Dodd & Kenneth H. Tonge	Unit/s (4.1,4.2)
4.	Analytical chemistry David Harvey The ,McGraw Hill Companies, Inc.	Unit/s (4.1,4.2)
5.	Analytical Chemistry, Gary.D Christan, 5th edition	Unit/s (2.1,2.2)
6.	Analytical chemistry, R. K. Dave.	Unit/s (2.3)
7.	Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969	Unit/s (2.1,2.2)
8.	Egyankosh.ac.in/bitstream/123456789/43329/1/Unit-8	Unit/s (1.1,1.2)
9.	Food Analysis, Edited by S. Suzanne Nielsen, Springer	Unit/s (3.1,3.2)
10.	Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan, Springer	Unit/s (3.1,3.2)
11.	Formulation and Function of cosmetics, Sa Jellineck	Unit/s (3.2)
12.	Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt., Saunders 6th Edition (1992)	Unit/s (2.1,2.2,2.3)(4.1,4.2)
13.	Government of India publications of food drug cosmetic act and rules.	Unit/s (3.1,3.2)
14.	Harry's Cosmetology, Longman scientific co.	Unit/s (3.2)
15.	High Performance Thin Layer Chromatography in Food analysis, by Prem kumar, CBS Publisher and distributer	Unit/s (2.2)
16.	Instrumental methods Of Analysis, by Willard Merritt Dean, 7thEdition, CBS Publisher and distribution Pvt Ltd	Unit/s (1.1,1.2) (4.1,4.2)
17.	Introduction to Polarography and Allied Techniques, By Kamala Zutshi, New Age International, 2006.	Unit/s (1.1,1.2)
18.	Modern cosmetics, E. Thomessen Wiley Inter science	Unit/s (3.2)

## PRACTICALS

Course Code: USCHP604

Credits: 02

### Non-Instrumental Experiments

1. Estimation of reducing sugar in honey by Willstatter method.
2. Estimation of magnesium content in Talcum powder by complexometric titration, using standardized solution of EDTA.
3. Estimation of Sodium using cation exchanger.

### Instrumental Experiments

1. Estimation of acetic acid in Vinegar sample by using Quinhydrone electrode potentiometrically.
2. Determination of phosphoric acid in cola sample pH metrically.
3. Determination of the amount of fluoride in the given solution colorimetrically/ spectrophotometrically.

### References:

1.	Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn., G. H. Jeffery, J Bassett, J Mendham and R C Denney, ELBS with Longmann (1989).
2.	Vogel's Textbook of Quantitative Chemical analysis, Sixth edition, J.Mendham et.al
3.	The chemical analysis of food and food products III edition Morris Jacob
4.	The chemical analysis of food by David Pearson and Henry Edward

## Evaluation Pattern for Semesters V and VI

### Semester End Theory Examination

<b>Internal Continuous Assessment: 25% (25 Marks)</b>	<b>Semester End Examination: 75% (75 Marks)</b>	<b>Duration for End Semester Examination</b>
<b>Continuous Evaluation through:</b> Quizzes, Class Tests, Presentations, Projects, Role Plays, Creative Writings, Assignments, etc.	As per following pattern	2 hrs 30 minutes

### Pattern for Semester End Examination (75 Marks):

1. Duration - This examination shall be of **Two hours and 30 minutes** duration.
2. Theory question paper pattern:
  - a. There shall be **05** questions each of **15 marks**.
  - b. All questions shall be compulsory with internal choice within the questions.

<b>Question</b>	<b>Option</b>	<b>Marks</b>	<b>Based on Units</b>
Q.1	Subjective questions 3 out of 5	15	Unit I
Q.2	Subjective questions 3 out of 5	15	Unit II
Q.3	Subjective questions 3 out of 5	15	Unit III
Q.4	Subjective questions 3 out of 5	15	Unit IV
Q.5	A. True or False (Any Five out of Eight)	05	All Units
	B. Fill in the Blank with correct alternative. (MCQs with Four Options) (Any Five out of Eight)	05	
	C. Match the following (Any Five out of Eight)	05	
Total		<b>75</b>	--

## **Practical**

1. Total Marks for Practical Examination per major component is 50 Marks.
2. Every student shall perform **one experiment** from each Major Component
3. Scheme of Examination:
  - a. Experiment : 40 Marks
  - b. Journal : 05 Marks
  - c. Viva-Voce : 05 Marks

**Total : 50 Marks**

## **Practical Book/Journal:**

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

**Sign of the BOS  
Coordinator  
Dr. Sunil Patil  
BOS in Chemistry**

**Sign of the  
Offg. Associate Dean  
Dr. Madhav R. Rajwade  
Faculty of Science &  
Technology**

**Sign of the  
Offg. Dean  
Prof. Shivram S. Garje  
Faculty of Science &  
Technology**