UNIVERSITY OF MUMBAI

No. UG/73of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/156 of 2016-17, dated 16th November, 2016 relating to syllabus of the Bachelor of Science (B.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 28th May, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.41 and that in accordance therewith, 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 has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
6th ~~June~~ July, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.41/14/06/2018

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No. UG/ 73 -A of 2018 MUMBAI-400 032 6th ~~June~~ July, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

T.Y.B.Sc. CHEMISTRY (6 UNITS)
Choice Based Semester and Grading System
To be implemented from the Academic year 2018-2019

SEMESTER V

PHYSICAL CHEMISTRY

COURSE CODE: USCH502 CREDITS: 02 LECTURES: 60

UNIT	TOPIC	NO. OF Lectures
UNIT I	1.0 MOLECULAR SPECTROSCOPY	15L
	1.1 **Rotational Spectrum**: Introduction to dipole moment, polarization of a bond, bond moment, molecular structure, .Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of internuclear distance and isotopic shift. 1.2 **Vibrational spectrum**: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum. 1.3 **Vibrational-Rotational spectrum of diatomic molecule**: energy levels, selection rule, nature of spectrum, P and R branch lines. Anharmonic oscillator - energy levels, selection rule, fundamental band, overtones. Application of vibrational-rotational spectrum in determination of force constant and its significance. Infrared spectra of simple molecules like H_2O and CO_2. 1.4 **Raman Spectroscopy :** Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion- CO_2 molecule.	
UNIT II	2.0 CHEMICAL THERMODYNAMICS	10 L
	2.1.1**Colligative properties:** Vapour pressure and relative lowering of vapour pressure. Measurement of lowering of vapour pressure - Static and Dynamic method.	
	2.1.2 **Solutions of Solid in Liquid:** 2.1.2.1 Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute. 2.1.2.2 Depression in freezing point of a solution, thermodynamic	

	derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. Beckmann Method and Rast Method.	
	2.1.3 **Osmotic Pressure :** Introduction, thermodynamic derivation of Van't Hoff equation, Van't Hoff Factor. Measurement of Osmotic Pressure - Berkeley and Hartley's Method, Reverse Osmosis.	
	2.2 CHEMICAL KINETICS	5 L
	2.2.1 **Collision theory of reaction rates** : Application of collision theory to 1. Unimolecular reaction Lindemann theory and 2. Bimolecular reaction. (derivation expected for both) 2.2.2 Classification of reactions as slow, fast and ultra -fast. Study of kinetics of fast reactions by Stop flow method and Flash photolysis (No derivation expected).	
UNIT III	3.0 NUCLEAR CHEMISTRY	15L
	3.1. **Introduction**: **B**asic terms-radioactive constants (decay constant, half life and average life) and units of radioactivity	
	3.2 **Detection and Measurement of Radioactivity:** Types and characteristics of nuclear radiations, behaviour of ion pairs in electric field, detection and measurement of nuclear radiations using G. M. Counter and Scintillation Counter.	
	3.3 **Application of use of radioisotopes as Tracers :** chemical reaction mechanism, age determination - dating by C^{14}.	
	3.4 **Nuclear reactions**: nuclear transmutation (one example for each projectile), artificial radioactivity, Q - value of nuclear reaction, threshold energy.	
	3.5 **Fission Process :** Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process. multiplication factor and critical size or mass of fissionable material, nuclear power reactor and breeder reactor.	
	3.6 **Fusion Process :** Thermonuclear reactions occurring on stellar bodies and earth.	
UNIT IV	4.1 SURFACE CHEMISTRY	6L
	4.1.1 **Adsorption:** Physical and Chemical Adsorption, types of adsorption isotherms . Langmuir's adsorption isotherm (Postulates and derivation expected). B.E.T. equation for multilayer adsorption, (derivation not expected). Determination of surface area of an adsorbent using B.E.T. equation.	
	4.2 COLLOIDAL STATE	9L
	4.2.1 **Introduction to colloids** - Emulsions, Gels and Sols	
	4.2.2 **Electrical Properties** : 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 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. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.

2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota.

3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]

4. Physical Chemistry, G. Castellan, 3rd edition, 5th Reprint, 1995 Narosa Publishing House.

5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer

6. Fundamental of Molecular Spectroscopy, 4th Edn., Colin N Banwell and Elaine M McCash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.

7. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.

8. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford Universtity Press Oxford.

9. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.

10. Principles of Physical Chemistry B.R. Puri, L.R. Sharma, M.S. Pathania, VISHAL PUBLISHING Company, 2008.

11. Textbook of Polymer Science, Fred W Bilmeyer, John Wiley & Sons (Asia) Ple. Ltd., Singapore, 2007.

12. Polymer Science, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.

13. Essentials of Nuclear Chemistry, Arnikar, Hari Jeevan , New Age International (P) Ltd., Publishers, 2011..

14. Chemical Kinetics,K. Laidler, Pearson Education India, 1987.

T.Y.B.Sc Physical Chemistry Practical

SEMESTER V

PHYSICAL CHEMISTRY

COURSE CODE: USCHP01

CREDITS: 02

Non-Instrumental

Colligative properties

To determine the molecular weight of compound by Rast Method

Chemical Kinetics

To determine the order between $K_2S_2O_8$ and KI by fractional change method. **(six units and three units)**

Surface phenomena

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

Instrumental

Potentiometry

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

Conductometry

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

pH-metry

To determine acidic and basic dissociation constants of amino acid and hence to calculate 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

SEMESTER VI

PHYSICAL CHEMISTRY

COURSE CODE: USCH601 CREDITS: 02

LECTURES: 60

UNIT I	1.1 ELECTROCHEMISTRY	7L
	1.1.1 **Activity and Activity Coefficient:** 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).	
	1.1.2 **Classification of cells:** Chemical cells and Concentration cells. Chemical cells with and without transference, Electrode Concentration cells, Electrolyte concentration cells with and without transference	

	(derivations are expected),	
	1.2 APPLIED ELECTROCHEMISTRY	8L
	1.2.1 **Polarization**: concentration polarization and it's elimination	
	1.2.2 **Decomposition Potential and Overvoltage** : Introduction, experimental determination of decomposition potential, factors affecting decomposition potential. Tafel's equation for hydrogen overvoltage, experimental determination of over –voltage	
UNIT II	2.0 POLYMERS	15L
	2.1 **Basic terms :** macromolecule, monomer, repeat unit, degree of polymerization.	
	2.2. **Classification of polymers:** Classification based on source, structure, thermal response and physical properties.	
	2.3. **Molar masses of polymers:** Number average, Weight average, Viscosity average molar mass, Monodispersity and Polydispersity	
	2.4. **Method of determining molar masses of polymers :** Viscosity method using Ostwald Viscometer. (derivation expected)	
	2.5. **Light Emitting Polymers :** Introduction, Characteristics, Method of preparation and applications.	
	2.6. **Antioxidants and Stabilizers :** Antioxidants , Ultraviolet stabilizers, Colourants, Antistatic agents and Curing agents.	
UNIT III	3.1 BASICS OF QUANTUM CHEMISTRY	10 L
	3.1.1 **Classical mechanics**: Introduction, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect.	
	3.1.2 **Quantum mechanics :** Introduction, Planck's theory of quantization, wave particle duality, de –Broglie's equation, Heisenberg's uncertainty principle.	
	3.1.3 **Progressive and standing waves-** Introduction, boundary conditions, Schrodinger's time independent wave equation (No derivation expected), interpretation and properties of wave function.	
	3.1.4 **Quantum mechanics** : State function and its significance, Concept of operators - definition, addition, subtraction and multiplication of operators, commutative and non - commutative operators, linear operator, Hamiltonian operator, Eigen function and Eigen value.	
	3.2 RENEWABLE ENERGY RESOURCES	5L
	3.2.1. **Renewable energy resources** : Introduction.	
	3.2.2 **Solar energy**: Solar cells, Photovoltaic effect, Differences between conductors,semiconductors ,insulators and its band gap, Semiconductors as solar energy converters, Silicon solar cell	
	3.2.3. **Hydrogen :** Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium.	

UNIT IV	4.1 NMR -NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY	7L
	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). **4.1.2. Instrumentation**: NMR Spectrometer	
	4.2 ELECTRON SPIN RESONANCE SPECTROSCOPY	
	4.2.1. Principle: fundamental equation, g-value -dimensionless constant or electron g-factor, hyperfine splitting. **4.2.2. Instrumentation**: ESR spectrometer, ESR spectrum of hydrogen and deuterium.	8L

Note : Numericals and Word Problems are Expected from All Units

Reference Books :

1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.

2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota.

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14. Chemical Kinetics,K. Laidler, Pearson Education India, 1987.

T.Y.B.Sc Physical Chemistry Practical

SEMESTER VI

PHYSICAL CHEMISTRY

COURSE CODE: USCHP02 **CREDITS: 02**

Non-Instrumental

Chemical Kinetics

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

(No fractional order)

Viscosity

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

Instrumental

Potentiometry

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

To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and cerric sulphate potentiometrically.

Conductometry

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

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

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

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UNIVERSITY OF MUMBAI

No. UG/73of 2018-19

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(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
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A.C./4.41/14/06/2018

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No. UG/ 73 -A of 2018 MUMBAI-400 032 6th ~~June~~ July, 2018

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4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

T.Y.B.Sc, CHEMISTRY (Six Units)

SEMESTER V

ORGANIC CHEMISTRY

COURSE CODE: USCH503 **CREDITS: 02** **LECTURES: 60**

Unit I

1.1 Mechanism of organic reactions (10 L)

1.1.1 The basic terms & concepts: bond fission, reaction intermediates, electrophiles & nucleophiles, ligand, base, electrophilicity vs. acidity & nucleophilicity vs basicity.

1.1.2 Neighbouring group participation in nucleophilic substitution reactions**:** participation of lone pair of electrons, kinetics and stereochemical outcome.

1.1.3 Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalyzed esterification of carboxylic acids ($A_{AC}2$) and base promoted hydrolysis of esters ($B_{AC}2$).

1.1.4 Pericyclic reactions, classification and nomenclature

1.1.4.1 Electro cyclic reactions (ring opening and ring closing), cycloaddition, sigma tropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type)

1.1.4.2 Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates

References:

1. A guidebook to mechanism in Organic Chemistry, 6th edition, Peter Sykes, Pearson education, New Delhi
2. Organic Reaction Mechanism, 4th edition, V. K. Ahluwalia, R. K. Parashar, Narosa Publication.
3. Organic reactions & their mechanisms,3rd revised edition, P.S. Kalsi, New Age International Publishers.
4. M.B.Smith and J. March, Advanced organic chemistry- reactions mechanism and structure, 5th edition.

1.2 Photochemistry (5 L)

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- π methane)

1.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages. Photo reduction (e.g. benzophenone to benzpinacol)

References:

1. Organic Chemistry, 7th Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
2. Organic chemistry,8th edition, John Mc Murry

Unit II

2.1 Stereochemistry I (5 L)

2.1.1 Molecular chirality and elements of symmetry: Mirror plane symmetry, inversion center, roation -reflection (alternating) axis.

2.1.2 Chirality of compounds without a stereo genic center: cummulenes and biphenyls.

References:

1. L. Eliel , stereochemistry of carbon compounds, Tata McGraw Hill
2. Stereochemistry P.S.Kalsi , New Age International Ltd.,4th Edition
3. Stereochemistry by Nassipuri.

2.2 Agrochemicals (4 L)

2.2.1 General introduction & scope, meaning & examples of insecticides, herbicides, fungicide, rodenticide, pesticides, plant growth regulators.

2.2.2 Advantages & disadvantages of agrochemicals

2.2.3 Synthesis & application of IAA (Indole Acetic Acid) & Endosulphan,

2.2.4 Bio pesticides – Neem oil & Karanj oil.

References:

1. Insecticides & pesticides: Saxena A. B., Anmol publication.
2. Growth regulators in Agriculture & Horticulture: Amarjit Basra, CRC press 2000.
3. Agrochemicals and pesticides: A.Jadhav and T.V.Sathe.

2.3 Heterocyclic chemistry: (6 L)

2.3.1 Reactivity of pyridine-N-oxide, quinoline and iso-quionoline.

2.3.2 Preparation of pyridine-N-oxide, quinoline (Skraup synthesis) and iso-quinoline (Bischler-Napieralski synthesis).

2.3.3 Reactions of pyridine-N-oxide: halogenation, nitration and reaction with $NaNH_2$/liq.NH_3, n-BuLi.

2.3.4 Reactions of quinoline and isoquinoline; oxidation,reduction,nitration,halogenation and reaction with $NaNH_2$/liq.NH_3,n-BuLi.

References

1. Name Reactions in Heterocyclic Chemistry, Jie-Jack Li, Wiley-Interscience publications, 2005.
2. Handbook of Heterocyclic Chemistry, 2nd Edition, Alan R. Katritzky and Alexander F. Pozharskii, Elsevier Science Ltd, 2000.
3. Heterocyclic Chemistry, 5th Edition, John A. Joule and Keith Mills, Wiley publication, 2010.
4. Heterocyclic chemistry, 3rd Edition, Thomas L. Gilchrist, Pearson Education, 2007.

Unit III

3.1 IUPAC (5 L)

IUPAC Systematic nomenclature of the following classes of compounds (including compounds upto two substituents / functional groups):

3.1.1 Bicyclic compounds – spiro, fused and bridged (upto 11 carbon atoms) – saturated and unsaturated compounds.

3.1.2 Biphenyls

3.1.3 Cummulenes with upto 3 double bonds

3.1.4 Quinolines and isoquinolines

References

1. Nomenclature of Organic Chemistry**:** IUPAC recommendations and preferred Names 2013, RSC publication.
2. IUPAC nomenclature by S.C.Pal.

3.2 Synthesis of organic compounds (10L)

3.2.1 Introduction: Linear and convergent synthesis, criteria for an ideal synthesis, concept of chemo selectivity and regioselectivity with examples, calculation of yields.

3.2.2 Multicomponent Synthesis: Mannich reaction and Biginelli reaction. Synthesis with examples (no mechanism)

3.2.3 Green chemistry and synthesis:

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_2
iv) Green catalysts: Bio catalysts.

3.2.4 Planning of organic synthesis

i) synthesis of nitroanilines. (*o&p*)
ii) synthesis of halobenzoic acid.(*o&p*)
iii) Alcohols (primary / secondary / tertiary) using Grignard reagents.
iv) Alkanes (using organo lithium compounds)

Reference:

1. Green chemistry an introductory text : Mike Lancaster.
2. Green chemistry: V. K. Ahluwalia (Narosa publishing house pvt. ltd.)
3. Green chemistry an introductory text : RSC publishing.
4. New trends in green chemistry V. K. Ahluwalia , M. Kidwai, Klumer Academic publisher
5. Green chemistry by V. Kumar.
6. Organic chemistry: Francis Carey
7. Organic chemistry: Carey and Sundberg.

Unit IV

4.1 Spectroscopy I (5 L)

4.1.1 Introduction: Electromagnetic spectrum, units of wavelength and frequency

4.1.2 UV – Visible spectroscopy: 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.

4.1.3 Mass spectrometry: Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, nitrogen rule, rule of 13 for determination of empirical formula and molecular formula. Fragmentation of alkanes and aliphatic carbonyl compounds.

References:

1. Organic spectroscopy (Second edition),Jag Mohan ,Narosa publication
2. Spectroscopy, Pavia, Lampman, Kriz,Vyvyan.

3. Elementary organic spectroscopy (Third edition), Y.R.Sharma, S.Chand publication..
4. Introduction to spectroscopy (third edition), Pavia ,Lampman,Kriz,john vondeling,Emily Barrosse.
5. Organic chemistry Paula Y. Bruice, Pearson education.
6. Spectral identification of organic molecules by Silverstein.
7. Absorption spectroscopy of organic molecules by V.M.Parikh.

4.2 Natural Products: (10L)

4.2.1. Terpenoids: Introduction, Isoprene rule, special isoprene rule and the gem-dialkyl rule.

4.2.2 Citral:

a) Structural determination of citral.
b) Synthesis of citral from methyl heptenone
c) Isomerism in citral. (cis and trans form).

4.2.3. Alkaloids Introduction and occurrence.

Hofmann's exhaustive methylation and degradation in**:** simple open chain and N – substituted monocyclic amines.

4.2.4 Nicotine:

a) Structural determination of nicotine. (Pinner's work included)
b) Synthesis of nicotine from nicotinic acid
c) Harmful effects of nicotine.

4.2.5 Hormones:

Introduction, structure of adrenaline (epinephrine), physiological action of adrenaline.
Synthesis of adrenaline from

a) Catechol
b) p-hydroxybenzaldehyde(Ott's synthesis)

References:

1. Chemistry of natural products by Chatwal Anand – Vol I and Vol II
2. Chemistry of natural products by O.P. Agarwal
3. Chemistry of natural products by Meenakshi Sivakumar and Sujata Bhat.
4. Organic chemistry by Morrision and Boyd,7th edition.
5. I.L.Finar,Vol-I and Vol-II, 5th edition.

PRACTICALS

SEMESTER V

ORGANIC CHEMISTRY

COURSE CODE: USCHP09 **CREDITS: 02**

A) SEMESTER V: 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 bases

(nitroanilines) , water soluble neutral (thiourea) and water insoluble neutral compounds (anilides , amides, m-DNB, hydrocarbons)

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..

References:

1. Practical organic chemistry – A. I. Vogel
2. Practical organic chemistry – H.Middleton.
3. Practical organic chemistry – O.P.Aggarwal.

SEMESTER VI

ORGANIC CHEMISTRY

COURSE CODE: USCH603 **CREDITS: 02** **LECTURES: 60**

Unit I

1.1 Stereochemistry II (10 L)

1.1.1 Stereoselectivity and stereospecificity: Idea of enantioselectivity (ee) and diastereoselectivity (de) , Topicity : enantiotopic and diasterotopic atoms, groups and faces.

1.1.2 Stereochemistry of –

i) Substitution reactions : S_{Ni} (reaction of alcohol with thionyl chloride)

ii) Elimination reactions: E_2–Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane.

iii) Addition reactions to olefins:

a) bromination (electrophilic anti addition)

b) syn hydroxylation with O_sO_4 and $KMnO_4$

c) epoxidation followed by hydrolysis.

References:

Refer Stereochemistry –I (Sem-V, Unit-II)

1.2 Amino acids & Proteins (5 L)

1.2.1 α-Amino acids: 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.

1.2.2 Polypeptides and Proteins: nature of peptide bond. Nomenclature and representation of polypeptides (di-and tri-peptides) with examples Merrifield solid phase polypeptide synthesis. .Protiens:general idea of primary,secondary,tertiary & quaternary structure

References:

1. Biochemistry, 8th Ed., Jeremy Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto Pub. W. H. Freeman Publishers
2. Lehninger Principles of Biochemistry 7th Ed., David Nelson and Michael Cox, Publisher W. H. Freeman
3. Name Reactions – Jie Jack Li, 4th Edition, Springer Pub.

Unit II

2.1 Molecular Rearrangements (5 L)

Mechanism of the following rearrangements with examples and stereochemistry wherever applicable.

2.1.1 Migration to the electron deficient carbon: Pinacol-pinacolone rearrangement.

2.1.2 Migration to the electron deficient nitrogen: Beckmann rearrangement.

2.1.3 Migration involving a carbanion : Favorski rearrangement.

2.1.4 Name reactions: Michael addition, Wittig reaction.

References:

Refer Mechanism of organic reaction (Sem-V, Unit-I)

2.2 Carbohydrates (10 L)

2.2.1 Introduction: classification, reducing and non-reducing sugars, DL notation

2.2.2 Structures of monosaccharides: 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

2.2.3 Stereoisomers of D-glucose: enantiomer, diastereomers, anomers, epimers.

2.2.4 Mutarotation in D-glucose with mechanism

2.2.5 Chain lengthening & shortening reactions: Modified Kiliani-Fischer synthesis (D-arabinose to D-glucose and D-mannose), Wohl method (D-glucose to D-arabinose)

2.2.6 Reactions of D-glucose and D-fructose:
(a) Osazone formation (b) reduction: Hi/Ni, $NaBH_4$ (c) oxidation: bromine water, HNO_3, HIO_4 (d) acetylation (e) methylation:(d) and (e) with cyclic pyranose forms

2.2.7 Glycosides: general structure

References:

1. Organic chemistry (fourth edition),G,Marc Loudon,Oxford University press.
2. Introduction to Organic Chemistry (Third edition), Andrew Streitwieser, Jr. Clayton H. Heathcock, Macmilan publishing.
3. Organic chemistry fourth edition, Morrision and Boyd.
4. Introduction to Organic chemistry,John McMurry.
5. Organic chemistry volume-1&2 (fifth and sixth edition) IL Finar.

Unit III

3.1 Spectroscopy II (10 L)

3.1.1 IR Spectroscopy: Basic theory, nature of IR spectrum, selection rule, fingerprint region.

3.1.2 PMR Spectroscopy: Basic theory of PMR, nature of PMR spectrum, chemical shift (δ unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, C≡C, C=O and benzene ring). Spin- spin coupling and

coupling constant. application of deuterium exchange technique. application of PMR in structure determination.

3.1.3 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to IR and PMR: (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 NMR spectroscopic technique are expected. (Index of hydrogen deficiency should be the first step in solving the problems).

References:

Refer spectroscopy –I, (Sem-V, Unit-IV)

3.2 Nucleic Acids **(5 L)**

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.

References:

1. Organic chemistry R.T.Morrison and R.N.Boyd, 6th edition, pearson education
2. S.H.Pine, organic chemistry 4th edition. McGraw Hill

Unit IV

4.1 Polymer **(8 L)**

4.1.1 Introduction: terms monomer, polymer, homopolymer, copolymer, thermo plastics and thermosets.

4.1.2 Addition polymers: polyethylene, polypropylene, teflon, polystyrene, PVC, Uses.

4.1.3 Condensation polymers: polyesters, polyamides, polyurethanes, polycarbonates, phenol formaldehyde resins.Uses

4.1.4 Stereochemistry of polymers: Tacticity, mechanism of stereochemical control of polymerization using Ziegler Natta catalysts.

4.1.5 Natural and synthetic rubbers: Polymerisation of isoprene: 1,2 and 1,4 addition (cis and trans), Styrene butadiene copolymer.

4.1.6 Additives to polymers: Plasticisers, stabilizers and fillers.

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)

References:

1. Polymer chemistry by M.G.Arora, K.Singh.
2. Polymer science – a text book by Ahluwalia and Mishra
3. Introduction to polymer chemistry - R.Seymour, Wiley Interscience.

4.2 Catalysts and Reagents **(7 L)**

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

4.2.1 Catalysts: Catalysts for hydrogenation:

a. Raney Nickel

b. Pt and PtO_2 (C=C, CN, NO_2, aromatic ring)
c. Pd/C : C=C, COCl→CHO (Rosenmund)
d. Lindlar catalyst: alkynes

d.2.2 Reagents**:**

a. $LiAlH_4$ (reduction of CO, COOR, CN,NO_2)
b. $NaBH_4$ (reduction of CO)
c. SeO_2 (Oxidation of CH_2 alpha to CO)
d. mCPBA (epoxidation of C=C)
e. NBS (allylic and benzylic bromination)

References:

1. Organic chemistry by Francis Carey – McGrawHill .
2. Oranic chemistry by Carey and Sundberg, Part A & B

PRACTICALS

SEMESTER VI

ORGANIC CHEMISTRY

COURSE CODE: USCHP10 **CREDITS: 02**

A) SEMESTER VI: Separation of Binary liquid-liquid and liquid- solid mixture.

1. Minimum Six mixtures to be completed by the students.
2. Components of the liq-liq mixture should include volatile liquids like acetone, methylacetate, ethylacetate, isopropylalcohol, ethyl alcohol, EMK and non volatile liquids like chlorobenzene , bromobenzene, aniline, N,N dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate.
3. Components of the liq- solid mixture should include volatile liquids like acetone, methylacetate, ethylacetate, 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.

References:

4. Practical organic chemistry – A. I. Vogel
5. Practical organic chemistry – H.Middleton.
6. Practical organic chemistry – O.P.Aggarwal.

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UNIVERSITY OF MUMBAI
No. UG/ /56 of 2016-17

CIRCULAR:-

A reference is invited to the Syllabi relating to the B.Sc. degree course , **vide** this office Circular No. UG/98 of 2015-16, dated 13th October, 2016 and the Principals of affiliated Colleges in Science are hereby informed that the recommendation made by the Ad-hoc Board of Studies in Chemistry at its meeting held on 7th July, 2016 has been accepted by the Academic Council meeting held on 14th July, 2016 **vide** item No. 4.13 and that in accordance therewith, the revised syllabus as per the Choice Based Credit System for T.Y. B.Sc. programme in Chemistry (Sem. V & VI), which are available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

16/11/16

(Dr.M.A.Khan)
REGISTRAR

MUMBAI – 400 032
16 November, 2016

To,

The Principals of the affiliated Colleges in Science.

A.C/4.13/14.07.2016

****

No. UG/ /56A of 2016 MUMBAI-400 032 16 November, 2016

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculties of Science,
2) The Chairman, Board of Studies in Chemistry,
3) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
4) The Director, Board of College and University Development,
5) The Co-Ordinator, University Computerization Centre,
6) The Controller of Examinations.

16/11/16

(Dr.M.A.Khan)
REGISTRAR

PTO..

UNIVERSITY OF MUMBAI

Syllabus for sem V & VI
Program: B.Sc.
Course: CHEMISTRY

(Credit Based Semester and Grading System with effect from the academic year 2016–2017)

T.Y.B.Sc.
CHEMISTRY
Credit Based Semester and Grading System
To be implemented from the Academic year 2016-2017

SEMESTER V
Theory

Course	UNIT	TOPICS	Credits	L / Week
USCH501	**I**	**1.1 Colligative Properties of Dilute Solutions (8L)** **1.1.1** Dilute solution, colligate properties, Raoult's law, relative lowering of vapour pressure. **1.1.2** Elevation in boiling point of a solution, thermodynamic derivation relating elevation in the boiling point of a solution and the molar mass of the non-volatile solute. **1.1.3** Depression in freezing point of a solution, thermodynamic derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. **1.1.4** Osmotic pressure, van't Hoff's equation for osmotic pressure, (derivation is expected) and determination of molar mass of the solute. Abnormal molar masses of solutes and van't Hoff factor (calculation of Degree of Association and Degree of Dissociation.) **1.2 Phase Rule (7L)** **1.2.1** Gibb's phase rule and terms involved in the equation. **1.2.2** Application of phase rule to ONE component systems (i) water system, (ii) sulphur system **1.2.3** Application of phase rule to TWO component systems, condensed systems, condensed phase rule, eutectic systems (Lead-Silver system), desilverisation of lead. **1.2.4** Introduction to three component system, explanation of phase diagram for three liquids forming one immiscible pair.	**2.5**	**1**

	II	**2.1 Surface Chemistry & Catalysis (9L)** **2.1.1 Adsorption:** Physical and Chemical Adsorption, types of adsorption isotherms **.** Langmuir's adsorption isotherm (Postulates and derivation expected). B.E.T. equation for multilayer adsorption, (derivation not expected). significance of the terms involved in the equation is expected.),determination of surface area of an adsorbent using B.E.T. equation. Numericals on surface area determination are expected. **2.1.2 Catalysis:** Homogeneous and heterogeneous catalysis, catalytic activity and selectivity, promoters, inhibitors, catalyst poisoning and deactivation, **2.1.3 Acid-Base catalysis**, mechanism and kinetics of acid-base catalyzed reactions, effect of pH on acid-base catalyzed reactions. Mechanism and kinetics of enzyme catalyzed reaction (Michaelis-Menten equation). **2.2 Colloids (6L)** **2.2.1** Introduction to colloidal state of matter. **2.2.2** Origin of charge on colloidal particles. Concept of electrical double layer, zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena:1.Electrophoresis, 2.Electrophoresis , 3. Streaming potential 4. Sedimentation potential . **2.2.3** Colloidal electrolytes. **2.2.4** Donnan Membrane Equilibrium. **2.2.5** Surfactants, micelle formation, applications of surfactants in detergents, food industry, in pesticide formulations.		
	III	**3.1 Electrochemistry – Electrochemical cells (15L)** **3.1.1** Lewis concept of Activity and Activity coefficient, Mean ionic activity and mean ionic activity coefficient γ_{+-} of an electrolyte, expression for activities of electrolytes of different valence type, ionic strength		

		3.1.2 Classification of cells: 1.chemical cells without transference 2.Concentration cells with and without transference (derivations of expression for concentration cell EMF are expected) Origin of liquid-liquid junction potential and its elimination using a salt bridge. **3.1.3** Applications of EMF .measurements in the determination of **1.** pH of a solution using quinhydrone and glass electrode. **2** solubility and solubility product of sparingly soluble salts using chemical cell and concentration cell method **3**. determination of liquid-liquid junction potential .		
	IV	**4.1 Introduction to Polymers (8L)** **4.1.1 Basic terms** : macromolecule, monomer, repeat unit, degree of polymerization. **4.1.2. Classification of polymers** based on (i) source, (ii) structure, (iii) thermal response, (iv) physical properties. **4.1.3. Molar masses of polymers**: 1. Number average molar mass, 2.Weight average molar mass, 3. Viscosity average molar mass, monodispersity, polydispersity. **4.1.4. Methods of determining molar masses of polymers** : 1. Ultrcentrifuge method (Limiting velocity method only). Viscosity method (Mark-Houwink equation). **4.1.5. Introduction to light emmiting polymers** (characteristics, method of preparation and it's application are expected). **4.2 Crystalline State (7L)** **4.2.1. Laws of Crystallography** **4.2.2**. Characteristics of simple cubic, face centered and body centered cubic system, inter planar distance in cubic lattices (only expressions for ratios of inter planar distances are expected). **4.2.3.** Use of X- rays in the study of crystal structure, Bragg's equation (derivation expected), X- ray diffraction method of studying crystal lattices, structure of NaCl and KCl,		**1**

		determination of Avagadro number. **4.2.4.** Elementary idea of defects in crystals- Frenkel defect and Schottky defect.		
USCH502	**I**	**1. Chemical Bonding And Solid State Chemistry (15L)** **1.1 Molecular Symmetry (7L)** **1.1.1** Introduction and Importance. **1.1.2** Symmetry elements and symmetry operations. **1.1.3** Concept of a Point Group with illustrations using the following point gro ups: (i) $C_{\alpha v}$ (HCl), (ii) $D_{\alpha h}$ (H_2), (iii) C2v (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans – trichloroethylene), and (vi) D_{3h} (BCl_3). **1.2 Molecular Orbital Theory for Polyatomic Species (5L)** **1.2.1** Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals). Term such as Walsh correlation diagram, Symmetry Adapted Linear Combinations (SALCs), Ligand Group orbitals (LGOs), transformation of atomic orbitals into appropriate symmetry types, expected to be discussed **1.3 (3L)** Other molecules (considering only σ-bonding): i) BeH_2, ii) H_2O, Explanation of terms viz.crystal lattice, lattice points, unit cells and lattice constants.	**2.5**	**1**

	II	**2. Solid Materials (15L)** **2.1 Structures of Solids (10L)** **2.1.1** Importance of solid state chemistry. **2.1.2** Classification of solids on the basis of bonding. **2.1.3** Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). Point defects with respect to Frenkel and Schottky defects expected. **2.1.4** Structure metallic solids. **2.1.5** Tetrahedral and octahedral interstitial voids in ccp lattice, tetrahedral holes,limiting radius ratios for different coordination numbers and their significance, calculation of limiting radius ratio for coordination number 4. **2.1.7** Structures of sodium chloride and cesium chloride. **2.2 Superconductivity (05L)** **2.2.1** Superconductivity, Meissner effect. **2.2.2** Different superconducting materials viz,convential superconductors, organic superconductors, alkali metal fullerides (A_3C_{60}) and high temperature Superconductors. **2.2.3** Applications of superconducting materials.		**1**
	III	**3. Chemistry of elements (15L)** **3.1 Inner transition elements (3L)** **3.1.1** Introduction: position of f-block elements and comparison between lanthanides and actinides **3.1.2** The shapes of *f*-orbitals. **3.1 Lanthanides Series (10L)** **3.2.1** Chemistry of lanthanides with reference to (i) lanthanide contraction, (ii) Oxidation states (iii) magnetic and spectral properties, **3.2.2** Occurrence, extraction and separation of lanthanides by Solvent extraction. **3.2.3** Applications of lanthanides.		**1**

		3.3 Actinides Series (2L) **3.3.1 Chemistry** of Uranium and with reference to occurrence, extraction (solvent extraction method), **3.3.2** Properties and applications.		
	IV	**4. Solution Chemistry** **4.1 Acid-base Chemistry in Aqueous Medium (8L)** **4.1.1 Acidity** of mono- and polyatomic cations. **4.1.2** Basicity of mono- and polyatomic anions (discussion for 4.1.1 as well as 4.1.2 to Include Latimer equation and predominance diagrams). **4.2 Chemistry in Non-aqueous Solvents (7L)** **4.2.1** Classification of solvents and importance of non-aqueous solvents. **4.2.2** Characteristics and study of liquid ammonia, dinitrogen tetraoxide and acetic acid as non-aqueous solvents with respect to (i) acid-base reactions and (ii) redox reactions.		**1**
USCH503	**I**	**1.1. Mechanism of Organic Reactions (15L)** 1.1.1 Thermodynamic and Kinetic control of organic reactions: Concept with mechanisms of the following reactions: addition of HX to butadiene; sulfonation of naphthalene. Nucleophilicity/ electrophilicity vs Basicity/acidity. 1.1.2 Mechanism of elimination reactions, with stereochemistry: E1 and E2 reactions: regioselectivity (Saytzeff and Hofmann rules). 1.1.3 Mechanism of reactions of carbonyl compounds with nucleophiles: 1.1.3.1 Formation of acetals/ketals from aldehydes and ketones. 1.1.3.2 Reaction of aldehydes and ketones with primary and secondary amines. 1.1.3.3 Acyl nucleophilic substitution (tetrahedral mechanism): Acid catalysed esterification of Carboxylic acids and base promoted hydrolysis of esters. 1.1.4 Mechanism of rearrangements with examples and stereochemistry wherever applicable. 1.1.4.1 Migration to electron deficient carbon: Pinacol,	**2.5**	**1**

		Benzylic acid. 1.1.4.2 Migration to electron deficient nitrogen: Beckmann, Hofmann. 1.1.5 Mechanism of the following reactons with synthetic application: Claisen condensation, Michael addition.		
	II	**2. Stereochemistry (15L)** 2.1.1 Molecular chirality and element of symmetry: Mirror Plane symmetry (inversion centre), rotation-reflection (alternating) axis, Chirality of compounds without stereogenic centre: cummulenes, spirans and biphenyls. 2.1.2 Stability ofcycloalkanes: Strains in cycloalkanes-angle,eclipising, transannular (3 to 8 membered). Conformations of cyclohexane, mono- and di- alkyl cyclohexanes and their relative stabilities. 2.1.3 Stereo selectivity and Stereo specificity: Idea of enantioselectivity (ee) and diastereoselectivity (de).Topicity-enantiotopic and diastereotopic atoms, groups and faces. **Stereochemistry of-** (1) Substitution reactions- S_N1, S_N2, S_Ni (reaction of alcohol with thionyl chloride). (2) E_2-anti-elimination-Base induced dehydrohalogenation of 1-bromo-1,2- diphenylpropane. (3) Addition reactions to olefins-i) catalytic hydrogenation ii) bromination (electrophilic anti addition) (iii)syn-hydroxylation (molecular addition) with OsO_4 and $KMnO_4$.		**1**
	III	**3.1 Carbohydrates (10L)** 3.1.1 Introduction: Classification, Sources, Reducing and non-reducing sugars DL notation. 3.1.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with stereochemistry of D-glucose and D-fructose. Stability of chair forms of D-		**1**

		glucose. 3.1.3 Determination of open chain configuration- of D-glucose assuming the configuration of D-arabinose; and of D-fructose assuming the configuration of D-glucose. 3.1.4 Anomers and epimers of monosaccharides. Enantiomers and diastereomers of glucose. Mutarotation (with mechanism) in D-glucose. 3.1.5 Chain lengthening and shortening reaction: Modified kiliani-fischer synthesis. Wohl method. 3.1.6 Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c)oxidation- bromine water, HNO_3, HIO_4. D) interconversion of D-glucose and D-fructose e) acetylation f) methylation [e and f with cyclic pyranose form]. 3.1.7 Commercial importance of carbohydrates in pharmaceutical, paper,food and Textile industries. **3.2. IUPAC Nomenclature (5L)** IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/ functional groups): **3.2.1** (a)Bicyclic compounds- spiro-,fused, and bridged (upto 11carbon atoms)-saturated and unsaturated compounds. **3.2.2** (b) Biphenyls. **3.2.3** (c) Cummulenes upto 3 double bonds (d) Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atoms among N,O,S. **3.1.1**Introduction:Classification, Sources, Reducing and non-reducing sugars DL notation. **3.1.2** Structures of monosaccharides: Fischer projection (4- 6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with		

		stereochemistry of D-glucose and D-fructose. Stability of chair forms of D-glucose. **3.1.3** Determination of open chain configuration- of D-glucose assuming the configuration of D-arabinose; and of D-fructose assuming the configuration of D-glucose. **3.1.4** Anomers and epimers of monosaccharides. Enantiomers and diastereomers glucose. Mutarotation (with mechanism) in D-glucose. **3.1.5** Chain lengthening and shortening reaction: Modified kiliani-fischer synthesis. Wohl method. **3.1.6** Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c)oxidation-bromine water, HNO_3, HIO_4. D) interconversion of D-glucose and D-fructose e) acetylation f) methylation [e and f with cyclic pyranose form]. **3.2. IUPAC Nomenclature (5L)** IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/functional groups): **3.2.1** (a)Bicyclic compounds- spiro-,fused, and bridged (upto 11carbon atoms)-saturated and unsaturated compounds. **3.2.2** (b) Biphenyls. **3.2.3** (c) Cummulenes upto 3 double bonds (d) Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atoms among N,O,S.		
	IV	**4.1. Heterocyclic Chemistry (8L)** **4.1.1** Introduction: Electronic structure and aromaticity of furan, pyrrole,thiophene and pyridine. **4.1.2** Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis. Pyridines by Hantzsch synthesis and from 1,5-diketones. **4.1.3** Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis		**1**

		of stability of intermediate; and of pyridine on the basis of electron distribution.Nucleophilic substitution reaction of pyridine on the basis of electron distribution. **4.1.4** Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Halogenation , Nitration, Sulphonation, Vilsmeir formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole -Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction.Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction).N-methylation of pyridine. Quaternization of piperdine, pyrrolidine and Hofmann elimination of the quaternary salts. **4.2. Organic Synthesis (7L)** **4.2.1** Introduction: Criteria for ideal organic synthesis. Yield and selectivity. Multi- component synthesis – with examples, Mannich reaction, Hanztsch synthesis of pyridines (without mechanism). **4.2.2** Illustrative synthesis of industrially important compounds: Ibuprofen (chiral synthesis), paracetamol (green synthesis), L-ascorbic acid (from D-glucose), norfloxacin, thyroxine, vanillin, methyl dihydrojasmonate (Hedione), Bifenox-I, pigment red 242, indigo, 2-hydroxy-3-amino-5-nitrobenzene sulphonic acid. **4.2.3** Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC. **4.1.1** Introduction: aromaticity of furan,pyrrole,thiophene and pyridine. **4.1.2** Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis. Pyridines by Hantzsch		

		synthesis and from 1,5-diketones. **4.1.3** Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis of stability of intermediate; and of pyridine on the basis of electron distribution. Nucleophilic substitution reaction of pyridine on the basis of electron distribution. **4.1.4** Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Vilsmeir formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole-Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction.Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction). N-methylation of pyridine.Quaternization of piperdine, pyrrolidine and Hofmann elimination of the quaternary salts. **4.2. Organic Synthesis (7L)** **4.2.1** Introduction: Criteria for ideal organic synthesis. Yield and selectivity. Multi- component synthesis – with examples, Mannich reaction, Hanztsch synthesis of pyridines (without mechanism). **4.2.2** Illustrative synthesis of industrially important compounds: Ibuprofen (chiral synthesis), paracetamol (green synthesis), L-ascorbic acid (from D-glucose), norfloxacin, nalidixic acid, vanillin, methyl dihydrojasmonate (Hedione), Bifenox-I, pigment red 242, 2-hydroxy-3-amino-5-nitrobenzene sulphonic acid. **4.2.3** Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC.		

USCH504	**I**	**1. Treatment of analytical data-I and sampling (15 L)** **1.1 Treatment of Analytical Data (7L)** Types of errors, determinate and indeterminate errors, minimization of errors, constant and proportionate errors, accuracy and precision, measures of dispersion and central tendency: mean, median, average deviation, relative average deviation, standard deviation, variance, coefficient of variation.[Numerical problems expected] **1.2 Sampling (8L)** Terms involved, importance of sampling, sampling techniques, sampling of gases, ambient and stack sampling, equipment used, sampling of homogeneous and heterogeneous liquids, sampling of static and flowing liquids, methods and equipments used, sampling of solids, importance of particle size and sample size, samples used, need for the reduction in the sample size, methods of reduction in sample size, collection, preservation and dissolution of the sample.	**2.5**	**1**
	II	**2. Titrimetric analysis-I and UV-Visible spectroscopy. (15L)** **2.1 Acid-base Titrations (5L)** Construction of titration curves and choice of indicators in the titration of [1] strong acid and strong base, [2] strong acid and weak base, [3] weak acid and strong base, [4] weak acid and weak base. **2.2 Precipitation titrations (4L)** Argentimetric titrations, construction of the titration curve, Volhard's method, Mohr's method, adsorption indicators, theory and applications**.** **2.3 U.V. Visible Spectroscopy (4L)** Photometers and spectrophotometers, Instrumentation in the case of single and double beam spectrophotometers, Qualitative and quantitative analysis, calibration cure method.		**1**

	III	**3. Methods of separation-I (15L)** **3.1 Solvent Extraction (8L)** Partition coefficient and distribution ratio, extraction efficiency, separation factor, role of complexing agents in solvent extraction, chelation, ion pair formation, solvation, types of solvent extraction: batch, continuous. [Numerical problems expected] **3.2 Chromatography (2L)** Introduction to chromatographic techniques, classification of chromatographic techniques. **3.3 Planar Chromatography (5L)** Principle, techniques and applications of [1] Paper chromatography [2] Thin layer chromatography		**1**
	IV	**4. Optical methods (15L)** **4.1 Atomic Spectroscopy (7L)** Absorption and emission spectra, energy level diagrams, process involved in atomization, flame photometry, flame atomizer, types of burners, monochromators and detectors, atomic absorption spectroscopy; flame and electrothermal atomizer, sources, instrumentation, quantitative applications of atomic absorption and flame photometry, calibration curve method, standard addition and internal standard method. **4.2 Molecular Fluorescence and Phosphorescence Spectroscopy (4L)** Theory, instrumentation and applications **4.3 Turbidimetry and Nephelometry (4L)** Scattering of light, effect of concentration, particle size and wavelength on light scattering, instrumentation and applications.		**1**

Practicals

USCHP05	**Practicals of Course USCH501** **<u>Physical Practicals</u>** **Chemical Kinetics –** To determine the order between $K_2S_2O_8$ & KI by fractional change method. **Viscosity** – To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement. **OR** To determine the radius of a glycerol molecule by viscosity measurement. **Potentiometry** – 1. To determine the amount of Fe(II) in the given solution by titration with a standard $K_2Cr_2O_7$ solution and hence to find the formal redox potential of Fe^{3+}/Fe^{2+} 2. To determine the solubility product and solubility of AgCl potentiometrically using chemical cell. **OR** 3. To determine the solubility product and solubility of AgCl potentiometrically using concentration cell. **Colorimetry –** To determine the amount of Fe(III) present in the given solution by using salicylic acid by colorimetric titration.(static method) (=525 nm) **pH –Metry –** To determine acidic and basic dissociation constants of amino acid hence to calculate isoelectric point. **Course USCH502** **<u>Inorganic Practicals</u>** **Inorganic preparations** 1. Potassium diaquo bis-(oxalate)cuprate (II)$K_2[Cu(C_2O_4)_2.(H_2O]$	**3**	**8**

	2. CuCl2-2DMSO 3. Bis(ethylene diamine)iron(II)sulphate[$C_2H_4(NH_2)_2FeSO_4.4H_2O$]. 4. Skill based Qualitative preparation of Chromium (II)acetate $Cr(OAc)_2$ so that the following outcomes are achieved: • Setting up reactor for Cr(II) ions • Identification of oxidation states of Chromium • Preparation of chromium(II)acetate • Isolation of the product		

	Volumetric analysis 1. Determination of magnesium from the supplied commercial sample of Milk of magnesia tablet 2. Estimation of Nickel(II)complexometrically using murexide indicator (Students are expected to standardize supplied EDTA solution using $ZnSO_4.7H_20$)		
USCHP06	**Practicals of Course USCH503** **Organic Practicals** i. Separation of binary (solid-slid) mixture.(Weights and physical constant of both crude components of the mixture are to be reported. (Minimum 4 mixtures) ii. Identification of an organic compound of known chemical type. (Minimum 4 mixtures) Syllabus for Organic Chemistry Sem-VI **Organic preparations** i. Acetylation of hydroquinone. ii. Nitration of nitrobenzene. iii. Hydrolysis of ethyl benzoate. iv. Bromination of acetanilide. **Course USCH504** **Analytical Practicals** 1. Estimation of persulphate in the given sample by the method of back titration. 2. Determination of the calcium and the magnesium content of a dolomite sample. 3. Determination of glucose content of a honey sample by Wilstater's method. 4. Determination of the amount of fluoride in the given solution colorimetrically. 5. Determination of Vitamin C content of a given tablet by titration with sodium hydroxide pH metrically	**3**	**8**

T.Y.B.Sc.
Chemistry
Credit Based Semester and Grading System
To be implemented from the Academic year 2016-2017

SEMESTER VI
Theory

Course	UNIT		Credits	L / Week
USCH601	I	**1.1 Molecular Spectroscopy –I (15L)** **1.1.1** Dipole moment: Dipole moment, polarization of a bond, bond moment, dipole moment and molecular structure. **1.1.2 Rotational Spectrum:** Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of inter nuclear distance and isotopic shift. **1.1.3 Vibration (IR) spectrum:** Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum. **1.1.4 Vibration-Rotation spectrum of diatomic molecule v**ibrating rotor, energy levels, selection rule, nature of spectrum, R and P branches, anharmonic oscillator : energy levels, selection rule, fundamental band, overtones . Application of vibration-rotation spectrum in determining Force constant, determination and significance. Introduction to infrared spectra of simple molecules like H_2O and CO_2 **1.1.5 Raman Spectroscopy :** Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum , Stoke's lines,anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion.(example of CO_2molecule).	**2.5**	**1**
	II	**2.1 Basics of Quantum Chemistry (10L)** **2.1.1** Classical mechanics, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect. **2.1.2** Introduction to quantum mechanics,		**1**

		Planck's theory of quantization, wave particle duality, de-Broglie equation, Heisenberg's uncertainty principle. **2.1.3** Progressive and standing waves, boundary conditions, Schrodinger's time independent wave equation(derivation not expected)., interpretation and properties of wave function. **2.1.4** Postulates of quantum mechanics (following are to be considered),1. state function and it's significance2. Concept of operators : definition, addition, subtraction and multiplication of operators, commutative and non- commutative operators, linear operator, Hamiltonian operator, 3. Eigen function and eigen value, eigen value equation. **2.2 Applied Electrochemistry (5L)** **2.2.1** Polarization, concentration polarization and it's elimination **2.2.2** Decomposition potential, experimental determination of decomposition potential, factors affecting decomposition potential (nature of electrolyte, nature of electrodes and temperature) Tafel's equation for hydrogen overvoltage, Overvoltage, experimental determination of over-voltage, **2.2.3** Electroplating ---objectives and procedures		
	III	**3.1 Renewable Energy Sources (5L)** **3.1.1.** Lithium ion cell. **3.1.2**. Fuel cells; Choice of fuel and oxidant, Bacon's H_2 and O_2 fuel cell. **3.1.3**. Solar cells, solar energy, photovoltaic effect, semiconductors as solar energy converters, silicon solar cell **3.1.4**. Hydrogen : Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium. **3.2 Nuclear Magnetic Resonance Spectroscopy (6L)** **3.2.1**. Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in n.m.r. (spin-spin relaxation and spin-lattice relaxation). **3.2.2**. NMR Spectrometer, chemical shift, shielding and deshielding of protons, low resolution n.m.r. spectrum of methanol and ethanol.		**1**

		3.3 Chemical Kinetics (4 L) **3.3.1** Collision theory of reaction rates, application of collision theory to 1. uni-molecular reaction and 2. bimolecular reaction (Lindemann theory, derivation expected). Merits and drawbacks of collision theory. **3.3.2** Classification of reactions as slow, fast and ultra-fast. study of kinetics of fast reactions by Stop flow method.		
	IV	**4.1 Nuclear Chemistry** **4.1.1** Types of nuclear radiations and their characteristics, behaviour of ion pairs in electric field, detecton and measurement of nuclear radiations using G. M. Counter and Scintillation Counter. **4.1.2** Kinetics of radioactive decay, units of radioactivity (Curie, Bequerel, Rutherford) **4.1.3** Radioactive equilibrium (secular and transient), determination of radioactive constants for radio-elements having 1. moderate half life, 2. long half life 3.extremely long or short half life. **4.1.4** Use of radioisotpes as tracers in 1. chemical investigations- reaction mechanism, 2. age determination- dating by carbon-14 **4.1.5** Nuclear reactions – nuclear transmutation, artificial radioactivity Q-value of nuclear reaction, threshold energy. **4.1.6** Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process. (multiplication factor and critical size or mass of fissionable material)., nuclear power reactor and breeder reactor.		**1**
USCH602	**I**	**Coordination Chemistry (15L)** **1.1 Crystal Field Theory (CFT)** **1.1.1** Basic tenets of Crystal field theory and effect of crystal field on central metal valence orbitals. **1.1.2** Splitting of *d* orbitals in octahedral, tetrahedral and square planar complexes. **1.1.3** Crystal field splitting energy ($10Dq$ or Δ_o) for octahedral complexes and factors affecting the magnitude of Δ_o. **1.1.4** Crystal field stabilization energy (CFSE), calculation of CFSE, for octahedral and tetrahedral complexes with	**2.5**	**1**

		d^1 to d^{10} metal ion configurations. **1.1.5** Effect of crystal field splitting on i) Ionic radius and ii) Lattice energy. **1.1.6** Theoretical failure of the CFT model. **1.1.7** Experimental evidence for co-valence in co-ordination compounds.(i) ESR spectrum of $[IrCl_6]^{2-}$ (ii) NMR spectrum of tris (acetyl acetanato) vanadium complex, (iii) Intensities of *d-d* transitions, and (iv) Nephelauxetic effect. Consequences of crystal field splitting on various properties such as ionic radii, hydration energy, lattice energy, enthalpies of formation, colour and magnetic properties. **1.2 Molecular Orbital Theory (MOT) of Coordination Complexes** **1.2.1** Application to octahedral complexes in case of (i) $[Ti(H_2O)]^{3+}$, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III). **1.2.2** Effect of pi-bonding an ligand field splitting parameter in M→L and L→M interactions. **1.3 Electronic States and Terms for Polyelectronic Atoms** **1.3.1** Introduction: electronic configuration and electronic states, Term symbols, coupling of spin momenta (M_S),orbital momenta (M_l)and spin- orbit coupling or Russell-Saunders coupling. **1.3.2** Determination of Terms for p^2 electronic configuration (as in a carbon atom). **1.3.3** Terms and micro-states for transition metal atoms/ions.		
	II	**2. Properties of Coordination compounds (15L)** **2.1 Stability of Complexes (5L)** **2.1.1** Thermodynamic stability and kinetic stability of complexes with examples. **2.1.2** Stability constants: Stepwise and overall constants and their inter-relationship. **2.1.3** Factors affecting thermodynamic stability. **2.1.4** Potentiometric method of determination of stability constants with example of silver-ammonia complex. **2.2 Substitution Reactions in Octahedral Complexes (5L)**		**1**

2.2.1 Introduction, types of reactions in complexes.
2.2.2 Ligand substitution reactions: basic mechanisms.
2.2.3 Inert and labile complexes and

		electronic configurations and lability of complexes. **2.2.4** Acid hydrolysis, base hydrolysis and anation reactions. **2.3 Electronic Spectra (5L)** **2.3.1** Types of electronic transitions like intra –ligand transitions, charge transfer transitions and intra-metal transitions and (*d-d* or ligand field transitions for transition metals). **2.3.2** Rules for electronic transitions: Spin and Orbital or Laporte selection rules. Orgel Diagrams for D Terms (i.e,d^1 , d^4 and d^6 .d^9 electronic configurations) and its use in interpretation of visible electronic absorption spectra of these configurations.		
	III	**Organometallic Chemistry (15L)** **3.1 Organometallic Compounds of main group metals (6L)** **3.1.1** Introduction: General synthetic methods: (i) Oxidative addition, (ii) Metal-Metal exchange (Transmetallation), (iii) Carbanion-Halide exchange, (iv) Metal Hydrogen exchange and (v) Methylene insertion reactions. **3.1.2** Chemical rections: (i) Reactions with oxygen, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents and (iv) Complex formation reactions. **3.2 Organometallic compounds of transition metals (9L)** **3.2.1** Synthesis , structure, reactions and of ferrocene. **3.2.2** Bonding in ferrocene on the basis of VBT. **3.2.3** Bonding in Re and Mo halide complexes.		**1**
	IV	**Some Selected Topics (15L)** **4.1 Inorganic Polymers (3L)** 4.1.1Various methods of classification with examples. **4.1.2** Chemistry of borazine with reference to preparation , properties, structures, bonding and applications. **4.2 Characteristics and Treatment**		**1**

		of Liquid Effluent (06L) **4.2.2** Characterization of waste: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), aerobic and anaerobic processes. **4.2.3** Removing of solid contaminants, physical and chemical principles such as coagulation, flocculation and sedimentation. **4.2.4** Primary,secondary and tertiary of liquid effluents. **4.3 Nanomaterials(04L)** **4.3.2** Introduction and importance of nanomaterials. **4.3.3** Properties (Comparison between bulk and nanomaterials): (i) Optical properties, (ii) Electrical conductivity, and (iii) Mechanical properties. **4.3.4** Forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires, and nanoparticles. **4.3.5** Chemical methods of preparation: (i) Colloidal route, and (ii) Sol-gel method. **4.5 Inorganic Pharmaceuticals (2L)** **4.4.2** Gastrointestinal agents viz., (i) antacids (aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) cathartics (magnesium sulphate and sodium phosphate). Topical agents viz., (i) protectives and adsorbents (talc, calamine), (ii) antimicrobial agents (potassium permanganate, tincture iodine, boric acid) and astringents (alum).		
USCH603	**I**	**1.1 Spectroscopy** (15L) 1.1.1 Introduction : Electromagnetic spectrum, units of wavelength and frequency. 1.1.2 UV- Visible Spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum, concept of Chromophore, auxochrome,bathochromic shift,Hypsochromic shift hyperchromic	**2.5**	**1**

		effect and chromophore-auxochrome interactions. 1.1.3 IR Spectrocopy: Basic theory, nature of IR spectrum, selection rule , fingerprint region. 1.1.4 PMR Spectroscopy: Basic theory of NMR, nature of PMR spectrum, chemical shift (∂ unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, CΞC, C=O and benzene ring). Spin- spin coupling and coupling constant. Proton exchange-application of deuterium exchange ,Application of PMR in structure determination. 1.1.5 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to UV-VIS, IR,PMR: (1)alkanes (2)alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10)amines (11) amides (broad regions characteristic of different groups are expected). 1.1.6 Mass Spectrometry: Basic theory.Nature of mass spectrum. General rules of fragmentation. Importance of - molecular ion peak, isotopic peaks, basepeak, Nitrogen rule.Illustrative fragmentation of alkanes and aliphatic carbonyl compounds (No Mclafferty rearrangement). 1.1.7 Problems of structure elucidation of simple organic compounds using individual or combined use of the above spectroscopic technique are expected.(index of hydrogen deficiency should be the first step in solving the problems).		
	II	**2.1 Polymers (11L)** 2.1.1 Introduction: General idea of monomers, polymers, and polymerization, natural and synthetic polymers. Homoplymers and copolymers. Classification of polymers- Plastic, fibres, resins, elastomers. Thermoplastics and thermosets. Copolymers-alternating, block, random, graft. 2.1.2 Mechanism of free radical addition		**1**

		polymerization. 2.1.3 Elastomers: Natural and synthetic rubbers. Diene polymerization: 1,2- and 1,4- addition (cis and trans) polymerization of isoprene. 1,3-Butadiene-styrene copolymer. 2.1.4 Stereochemistry of polymers: Tacticity. Role of Ziegler-Natta catalyst (co- ordination polymerization) in directing the tacticity in polypropylene (no mechanism). 2.1.5 Preparation & use of polymers: (1) Addition polymers: (a) polyethylene (b)polypropylene (c) PVC (d) polystyrene (e) polyacrylonitrile (f) polyvinylalcohol (g) Teflon. (2) Condensation Polymers: (a) Polyesters (b) polyamides (c) polyurethans (d)phenol-formaldehyde resin (e) epoxy resin (f) polycarbonates. 2.1.6 Recyclable polymers. Biodegradable polymers and their uses. Biomedical use of polymers. 2.1.7 Additives to polymers: Plasticizers ,stabilizers and fillers.(The students are expected to identify monomers in a given polymer and draw the structure of a polymer from a given set of monomers). **2.2 Photochemistry** 2.2.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triple states, allowed and forbidden transitions, fate of excited molecules, photosensitization. 2.2.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane) 2.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, Photo reduction (e.g. benzophenone to benzpinacol).		
	III	**3.1 Catalysts and Reagents (5L)** Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism). 3.1.1 **Catalysts** : Catalysts for **1** hydrogenation: Raney Ni,Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl→CHO (Rosenmund); Lindlar catalyst: alkynes; Wilkinson's catalyst for		

		stereo selective reduction of olefins. 3.1.2 **Reagents**: (1)$LiAlH_4$ and Red-Al: reduction of CO,COOR, CN, NO_2. (2) $NaBH_4$: reduction of CO (3) SeO_2: hydroxylation of allylic and benzylic positions,oxidation of CH_2, alpha to CO to CO.(5)mCPBA and R-OOH/H_2O_2 for epoxidation of C=C. (6) NBS: allylic and benzylic bromination of position alpha to CO. **3.2 Natural Products (10L)** 3.2.1 Introduction: Primary and secondary metabolites. Introduction to the following natural products with respect to the sources and classes. (Structures of the compounds specified below are expected). (a) Terpene: Isoprene and special isoprene rule.α-terpeniol, citral,camphor, α-pinene. (b) Alkaloids: nicotine,atropine. (c) Vitamins: Vitamins A and C. (d) Hormones: adrenaline, thyroxine. (e) Steroids: cholesterol, progesterone. 3.2.2 Structure determination of natural products: 3.2.2.1 Ozonolysis in terpenoids-Examples of open chain and monocyclic monoterpenes. 3.2.2.2 Hofmann exhaustive methylation and degradation in alkaloids – simple open chain and monocyclic amines.3.2.2.3 Structure determination of citral and nicotine through degradation studies. Total synthesis of degradation studies. Total synthesis of (i) Citral from 3-methylbutan-1-ol (ii) Nicotine from nicotinic acid. 3.2.4 Commercial importance of terpenoids and alkaloids: Synthesis of camphor from α-pinene, α and β ionones, geraniol and nerol from citral. 3.2.5		
	IV	**4.1 Organometallic Chemistry (5L)** 4.1.1 Intoduction: Carbon-metal bond-Nature, types reactivity. 4.1.2 **Organo magnesium Compounds**: Grignard reagent :Preparation, structure, and stability, Reaction with compounds containing acidic hydrogen,carbonyl compounds, cyanides and CO_2. 4.1.3 **Organolithium Compounds** : Preparation using alkyl/aryl halides. Reactions with compounds containing		**1**

		acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO_2. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides. 4.1.4 **Organozinc compounds**: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism). **4.2 Chemistry of some Important Biomolecules: (10L)** 4.2.1 α-Amino acids: Structure,configuration,Essential amino acids and their abbreviations, classification, Properties: pH dependency of ionic structure and isoelectric point. Methods of preparations: Strecker synthesis, amidomalonate synthesis, Erlenmeyer azalactone synthesis. 4.2.2 Polypeptides and Proteins: Polypeptides: Peptide bond. Nomenclature and representation of polypeptides. Merrifields solid phase peptide synthesis (example of di- and tri- peptides for nomenclature and synthesis). Proteins: Sources, types,functions,colloidal nature, separation based on isoelectric point, denaturation and functions. Partial and total hydrolysis. General idea of primary, secondary, tertiary and quartenary structures. 4.2.3 Nucleic acids: Selective hydrolysis of nucleic acids.Sugars and bases in nucleic acids. Stuctures of nucleosides an nucleotides in DNA and RNA. Structure of nucleic acids (DNA and RNA): Base pairing in nucleic acids. Importance of nucleic acids-self duplication, protein synthesis.		
USCH604	**I**	**Electroanalytical methods. (15L)** **1.1** D.C. Polaroghraphy (11L): Polarizable and nonpolarizable electrodes, basic principles, residual current, diffusion current, limiting current, dropping mercury electrode, supporting electrolyte half wave potential, derivation of the polarographic wave equation for a reversible reaction. Ilkovic equation, oxygen interference and its removal, maxima and maxima suppressors, polarographic cell, qualitative	**2.5**	**1**

		and quantitativeanalysis, calibration curve and standard addition method, applications. [Numerical problems expected] **1.2** Amperometric Titrations: Basic principles, rotating platinum electrode and nature of the titration curves, applications, advantages and limitations.		
	II	**Methods of separation-II (15L)** **2.1** Gas chromatography (6L): Gas liquid chromatography, basic principles retention time, retention volume, resolution, peak width theoretical plates. HETP, instrumentation, columns, detectors, applications. **2.2** High Performance Liquid Chromatography (4L): Instrumentation, types of elution, U.V. and I.R. detector and applications **2.3** Ion Exchange Chromatography (5L): Types of ion exchangers, mechanism of ion exchange, selectivity coefficients and separation factors, capacity and its determination, factors affecting the separation of ions, applications.		**1**
	III	**Treatment of analytical data-II and Titrimetric analysis-II (15L)** **3.1** Treatment of Analytical Data (6L): Distribution of random errors, Gaussian curve, students' t, confidence limits and confidence interval, criteria for rejection of result: 2.5d rule,4.0 rule and Q test, F teset, testing for significance, null hypothesis, method of averages, least squares method. Numerical problems expected] **3.2** Complexometric Titrations (5L): General introduction, EDTA titrations, advantages and limitations of EDTA as the titrant, absolute and conditional formation constants of metal EDTA complexes, construction of titration curves, types of EDTA titrations,methods of increasing the selectivity of EDTA as a titrant, metallochromic indicators, theory and applications. **3.3** Redox Titrations (4L): General introduction, theory of redox indicators, criterion for choosing an indicator for a redox titration, construction of the titration curves in the case of (1) Fe (II) Vs. Ce(IV)		**1**

		(2) Fe (II) Vs. dichromate, use of diphenyl amine and ferroin as redox indicators.		
	IV	**Concepts in Quality and miscellaneous methods (15L)** **4.1** Total quality management (5L) : concept of quality, quality control, quality assurance total quality management, ISO series, Good laboratory practices **4.2** Mass Spectrometry (2L): Basic principles, introduction of components only **4.3** Thermal Methods (5L): Classification of thermal methods, thermogravimetric analysis,basic principles, instrumentation factors affecting the TG curve, applications **4.4** Introduction to Radio Analytical Techniques (3L): Classification of the techniques, introduction to neutron activation analysis and its applications.		**1**

Practicals

USCHP07	**Practicals of Course USCH601** **<u>Physical Practicals</u>** **Chemical Kinetics –** To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate. **Partition coefficient** To determine the equilibrium constant for the reaction$KI + I_2 \rightleftharpoons KI_3$ by partition method. (Partion coefficient of I_2 between CCl_4 and water is to be given) **Potentiometry –** 1. To determine the strength of the given strong acid (HCl) by potentiometric titration using quinhydrone electrode (Calculation of pH from E_{cell} and the plot of (a) $\frac{\Delta E}{\Delta V}$ against V (b) pH against V graphs are expected). **OR** To determine pKa value of the given weak monobasic acid (CH_3COOH) by e.m.f. measurements. 2. To determine E_{cal} at room temperature	**3**	**8**

	and using this value, determine standard reduction potential of Ag/Ag^+ electrode at room temperature. **Conductometry –** To determine the amount of dibasic acid (Oxalic acid) by conductometric titration against strong base. **OR** To determine the relative strength of monochloroacetic acid and acetic acid conductometrically. **Course USCH602** **<u>Inorganic Practicals</u>** **Inorganic preparations** 1. Mercury tetrathiocyanato Cobaltate (II) $Hg[Co(SCN)_4]$ 2. Magnesium oxinate$[Mg(Ox)_2]$ 3. Tris-acetyl acetonato iron(III) $[Fe(AcAc)_3]$ 4. Tetrammine copper(II) sulphate. $[Cu(NH_3)_4]SO_4.H_2O$ **Inorganic estimations/ Analysis** 1. Estimation of copper iodometrically using sodium thiosulphate. (Students are expected to standardize supplied sodium thiosulphate solution using potassium dichromate) 2. Estimation of lead by complexomety using EDTA solution. (Students are expected to standardize the supplied EDTA solution. Suggested standard for standardization: $ZnSO_4.7H_2O$)		
USCHP08	**Practicals of Course USCH603** **<u>Organic Practicals</u>** **Binary Mixture Separation** Seperation of mixture containing (VL + NVL) & (S + VL) components. **Organic Preparations** 1. Aniline/p-toluidine → N-Acetyl derivative 2. Salicylic acid/nitrobenzene/ Acetanilide → Nitro derivative	**3**	**8**

	3. β- naphthol → Methyl Ether derivative (Using dimethyl sulphate) 4. Acetanilide → p-bromoacetanilide derivative 5. Aniline/ p-toluidine → Schiff base with benzaldehyde 6. Hydroquinone/beta naphthol → Acetyl derivative 7. Methyl salicylate/ethyl benzoate → Acid derivative (Hydrolysis) 8. Benzaldehyde/p-nitrobenzaldehyde → Acid (Oxidation) **Course USCH604** **<u>Analytical Practicals</u>** 1. Determination of chemical oxygen demand of a water sample. 2. Determination of percentage purity of a sample of common salt using a cation exchanger. 3. Determination of potassium content of a commercial salt sample by flame photometry. 4. Determination of acetic acid content of a vinegar sample by potentiometric titration with sodium hydroxide using quinhydrone. **5.** Determination of Cr (VI) in the given solution as dichromate by the method of least squares, spectrophotometrically		

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4. D.A. Skoog D.M. West and F.J. Holler, Fundametals of Analytical Chemistry, 7thEdition (printed in India in 2001) ISBN Publication.
5. Analytical Chemistry, J.G. Dick,1973 Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Quantitative analysis, Dey & Underwood, Prentice Hall of India, Pvt. Ltd.

New Delhi
7. Fundamentals of Analytical Chemistry, Skoog etal 8th edition, Saunders college publishing.

UNIVERSITY OF MUMBAI

No. UG/73of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/156 of 2016-17, dated 16th November, 2016 relating to syllabus of the Bachelor of Science (B.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 28th May, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.41 and that in accordance therewith, 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 has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
6th ~~June~~ July, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.41/14/06/2018

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No. UG/ 73 -A of 2018 MUMBAI-400 032 6th ~~June~~ July, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

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

Choice Based Semester and Grading System

SEMESTER V

INORGANIC CHEMISTRY

COURSE CODE: USCH502 **CREDITS: 02** **LECTURES: 60**

UNIT-I	**L/Week**
1. Molecular Symmetry and Chemical Bonding	
1.1Molecular Symmetry (6L)	
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}	
1.2 Molecular Orbital Theory for heteronuclear diatomic molecules and polyatomic species (9L)	
1.2.1 Comparision between homonuclear and heteronuclear diatomic molecules.	
1.2.2. Heteronuclear diatomic molecules like CO, NO and HCl, appreciation of modified MO diagram for CO.	
1.2.3 Molecular orbital theory for H_3 and H_3^+ (correlation diagram expected).	
1.2.4. Molecular shape to molecular orbital approach in AB_2 molecules. Application of symmetry concepts for linear and angular species considering σ- bonding only. (Examples like : i) BeH_2, ii) H_2O).	
UNIT-II	
2 SOLID STATE CHEMISTRY	
2.1 Structures of Solids (11L)	
2.2.1 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.	

2.1.3 Stoichiometric Point defects in solids (discussion on Frenkel and Schottky defects expected).	
2.2 Superconductivity (4L)	
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 fullerides, high temperature super conductors.	
2.2.4 Brief application of superconductors.	
UNIT-III	
3.0 CHEMISTRY OF INNER TRANSITION ELEMENTS (15L)	
3.1 Introduction: Position in periodic table and electronic configuration of lanthanides and actinides.	
3.2 Chemistry of Lanthanides with reference to (i) lanthanide contraction and its consequences(ii) Oxidation states (iii) Ability to form complexes (iv) Magnetic and spectral properties	
3.3 : Occurrence, extraction and separation of lanthanides by (i) Ion Exchange method and (ii) Solvent extraction method (Principles and technique)	
3.4 Applications of lanthanides	
UNIT-IV	
4. SOME SELECTED TOPICS	
4.1 Chemistry of Non-aqueous Solvents (5 L)	
4.1.1Classification of solvents and importance of non-aqueous solvents.	
4.1.2 Characteristics and study of liquid ammonia, dinitrogen tetra oxide as non-aqueous solvents with respect to : (i) acid-base reactions and (ii) redox reactions.	
4.2 Comparative Chemistry of Group 16 (5L)	
4.2.1 Electronic configurations, trends in physical properties, allotropy	
4.2.2 Manufacture of sulphuric acid by Contact process.	
4.3 Comparative Chemistry of Group 17 (5L)	
4.3.1Electronic configuration , General characteristics, anamolous properties of fluorine, comparative study of acidity of oxyacids of chlorine w.r.t acidity, oxidising properties and structures(on the basis of VSEPR theory)	
4.3.2 Chemistry of interhalogens with reference to preparations, properties and structures (on the basis of VSEPR theory) .	

REFERENCES

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

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 .

Unit-III

1. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6th 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

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, 4thEdn., ELBS,
4. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press
5. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6th 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

Practicals

SEMESTER V

INORGANIC CHEMISTRY

COURSE CODE: USCHP05 **CREDITS: 02**

Course USCH502: 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 cation and/or anion (qualitative analysis only by wet tests).

(Any three salts of transition metal ions)

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.

SEMESTER VI

INORGANIC CHEMISTRY

COURSE CODE: USCH602 CREDITS: 02 LECTURES: 60

COURSE CODE	**CREDITS**	
USCH602	**(60 Lectures)**	
(Numericals and word problems are expected)		
UNIT-I		**L/week**
1.Theories of the metal-ligand bond (I) (15L)		
1.1 Limitations of Valence Bond Theory.		
1.2 Crystal Field Theory and effect of crystal field on central metal valence orbitals in various geometries from linear to octahedral(from coordination number 2 to coordination number 6)		
1.3 Splitting of *d* orbitals in octahedral, square planar and tetrahedral crystal fields.		
1.4 Distortions from the octahedral geometry : (i) effect of ligand field and (ii) Jahn-Teller distortions.		
1.5 Crystal field splitting parameters Δ ; its calculation and factors affecting it in octahedral complexes, 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 and enthalpies of formation of metal complexes of the first transition series.		
1.8 Limitations of CFT : Evidences for covalence in metal complexes (i) intensities of d-d transitions, (ii) ESR spectrum of $[IrCl_6]^{2-}$ (iii) Nephelauxetic effect.		
UNIT-II		
2.Theories of the metal-ligand bond (II)		
2.1 Molecular orbital Theory for coordination compounds. (4L)		

2.1.1 Identification of the central metal orbitals and their symmetry suitable for formation of σ bonds with ligand orbitals.	
2.1.2 Construction of ligand group orbitals.	
2.1.3 Construction of σ-molecular orbitals for an ML_6 complex.	
2.1.4 Effect of π-bonding on complexes .	
2.1.5 Examples like $[FeF_6]^{-4}$, $[Fe(CN)_6]^{-4}$, $[FeF_6]^{-3}$, $[Fe(CN)_6]^{-3}$, $[CoF_6]^{-3}$, $[Co(NH_3)_6]^{+3}$	
2.2 Stability of Metal-Complexes (4L)	
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.	
2.3 Reactivity of metal complexes. (4L)	
2.3.1 Comparison between Inorganic and organic reactions.	
2.3.2 Types of reactions in metal complexes.	
2.3.3 Inert and labile complexes : correlation between electronic configurations and lability of complexes.	
2.3.4 Ligand substitution reactions : Associative and Dissociative mechanisms.	
2.2.5 Acid hydrolysis, base hydrolysis and anation reactions.	
2.4 Electronic Spectra. (3L)	
2.4.1Origin 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.	
UNIT-III	
3 ORGANOMETALLIC CHEMISTRY (15L)	
3.1 Organometallic Compounds of main group metal (6L)	
3.1.1General characteristics of various types of organometallic compounds, viz.ionic, σ-bonded and electron deficient compounds.	
3.1.2 General synthetic methods of organometallic compounds : (i) Oxidative-addition, (ii)Metal-metal exchange(transmetallation), (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, (iv) Redistribution reactions and (v) Complex formation reactions.	
3.2 Metallocenes (5L)	
Introduction, Ferrocene : Synthesis, properties, structure and bonding on the basis of VBT.	
3.3 Catalysis (4L)	
3.3.1 Comparison between homogeneous and heterogeneous catalysis	
3.3.2 Basic steps involved in homogeneous catalysis	
3.3.3 Mechanism of Wilkinson's catalyst in hydrogenation of alkenes.	
UNIT-IV	
4 SOME SELECTED TOPICS (15L)	
4.1 Metallurgy (7L)	
4.1.1 Types of metallurgies,	
4.1.2 General steps of metallurgy; Concentration of ore, calcinations, roasting,reduction and refining.	
4.1.3 Metallurgy of copper: occurrence, physicochemical principles, Extraction of copper from pyrites& refining by electrolysis.	
4.2 Chemistry of Group 18 (5L)	
4.2.1 Historical perspectives	
4.2.2 General characteristics and trends in physical and chemical properties	
4.2.3 Isolation of noble gases	
4.2.4 Compounds of Xenon (oxides and fluorides) with respect to preparation and structure (VSEPR)	
4.2.5 Uses of noble gases	
4.3 Introduction to Bioinorganic Chemistry. (3L)	
4.3.1Essential and non essential elements in biological systems.	
4.3.2 Biological importance of metal ions such as Na^{+},K^{+},Fe^{+2}/Fe^{+3} and Cu^{+2}(Role of Na^{+} and K^{+} w.r.t ion pump)	

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 Publishing House;
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

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

Unit-III:

1 Cotton, Wilkinson, Murillo and Bochmann, Advanced **Inorganic Chemistry**, 6th 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.

Unit-IV

1 R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
2 D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press
3 Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6th 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)

7 Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
8 Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
9 Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
10 Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry.S. Chand & Co Ltd

PRACTICALS

SEMESTER VI

INORGANIC CHEMISTRY

COURSE CODE: USCHP06 **CREDITS: 02**

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 cation and/or anion (qualitative analysis only by wet tests).

(Any three salts of main group metal ions)

Reference Books (practicals)

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

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

Choice Based Credit System

SEMESTER V

ANALYTICAL CHEMISTRY

COURSE CODE: USCH504 CREDITS: 02 LECTURES: 60

UNIT I :INTRODUCTION TO QUALITY CONCEPTS,CHEMICAL CALCULATIONS AND SAMPLING (3 & 6 UNITS)			
1.1	**Quality in Analytical Chemistry**		**05 L**
	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	
1.2	**Chemical Calculations (Numericals and word problems are expected)**		**04 L**
	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	
1.3	**Sampling**		**06 L**
	1.3.1	Purpose, significance and difficulties encountered in sampling	
	1.3.2	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.	
	1.3.3	Sampling of liquids: Homogeneous and heterogeneous, Static and flowing liquids.	
	1.3.4	Sampling of gases: Ambient and stack sampling: Apparatus and	

		methods for sampling of gases.	
	1.3.5	Collection, preservation and dissolution of the sample.	
UNIT II : CLASSICAL METHODS OF ANALYSIS (TITRIMETRY) (3 & 6 UNITS)			
2.1	**Redox Titrations (Numerical and word Problems are expected)**		**08 L**
	2.1.1	Introduction	
	2.1.2	Construction of the titration curves and calculation of E_{system} in aqueous medium in case of: (1) One electron system (2) Multielectron system	
	2.1.3	Theory of redox indicators, Criteria for selection of an indicator Use of diphenyl amine and ferroin as redox indicators	
2.2	**Complexometric Titrations**		**07 L**
	2.2.1	Introduction, construction of titration curve	
	2.2.2	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 with examples. Advantages and limitations of EDTA as a titrant.	
	2.2.3	Types of EDTA titrations.	
	2.2.4	Metallochromic indicators, theory, examples and applications	
UNIT III: OPTICAL METHODS(6 UNITS)			
3.1	**Atomic Spectroscopy: Flame Emission spectroscopy(FES) and Atomic Absorption Spectroscopy(AAS)**		**07 L**
	3.1.1	Introduction, Energy level diagrams, Atomic spectra, 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	Quantification methods of 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	
3.2	**Molecular Fluorescence and Phosphorescence Spectroscopy**		**04L**
	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	
3.3	**Turbidimetry and Nephelometry**		**04 L**
	3.3.1	Introduction and Principle	
	3.3.2	Factors affecting scattering of Radiation: Concentration, particle size, wavelength, refractive index	
	3.3.3	Instrumentation and Applications	
UNIT IV: METHODS OF SEPARATION – I (6 UNITS)			
4.1	**Solvent Extraction**		**06 L**
	4.1.1	Factors affecting 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.	
4.2	**High Performance Liquid chromatography (HPLC)**		**06L**
	4.2.1	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)	
	4.2.2	Qualitative and Quantitative Applications of HPLC	

4.3	**High Performance Thin Layer Chromatography (HPTLC)**		**03 L**
	4.3.1	Introduction and Principle Stationary phase, Sample application and mobile phase	
	4.3.2	Detectors a) Scanning densitometer- Components. Types of densitometer- Single beam and Double beam b) Fluorometric Detector	
	4.3.3	Advantages, disadvantages and applications	
	4.3.4	Comparison of TLC and HPTLC	

REFERENCES

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)
6.	Analytical Chromatography, Gurdeep R Chatwal, Himalaya publication	Unit/s (4.1,4.2,4.3)
7.	Basic Concepts of Analytical Chemistry, by S M Khopkar, new Age International (p) Limited	Unit/s (4.1,4.2,4.3)
8.	Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969	Unit/s (4.1,4.2,4.3)
9.	Fundamentals of Analytical Chemistry by Skoog and West , 8th Edition	Unit/s (4.1,4.2,4.3)
10.	Handbook of quality assurance for the analytical chemistry laboratory, 2ndEdn., James P. DuxVanNostr and Reinhold, 1990	Unit/s (1.1)
11.	High Performance Thin Layer Chromatography by Dr P.D. Sethi, CBS Publisher and Distribution	Unit/s(4.1,4.2,4.3)

12.	High Performance Thin Layer Chromatography in Food analysis, by Prem kumar, CBS Publisher and distributer	Unit/s (4.1,4.2,4.3)
13.	Instrumental methods of Analysis, by Dr Supriya S Mahajan, Popular Prakashan Ltd	Unit/s (4.1,4.2,4.3)
14.	Instrumental methods Of Analysis, by Willard Merritt Dean, 7thEdition, CBS Publisher and distribution Pvt Ltd	Unit/s (3.1,3.2,3.3)
15.	Instrumental Methods of Chemical Analysis by B.K. Sharma Goel Publishing House	Unit/s (4.1,4.2,4.3)
16.	Principles of Instrumental Analysis , 5th Edition, By Skoog, Holler, Nieman	Unit/s (4.1,4.2,4.3)(3.1,3.2,3.3)
17.	Quality control and Quality assurance in Analytical Chemical Laboratory, Piotr Konieczka and Jacek Namiesnik, CRC press (2018)	Unit/s (1.1)
18.	Quality in the Analytical Chemistry Laboratory, Elizabeth Prichard, Neil T. Crosby, Florence Elizabeth Prichard, John Wiley and Sons, 1995	Unit/s (1.1)
19.	Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969	Unit/s (4.1,4.2,4.3)
20. .	Thin Layer Chromatography, A LAB. Handbook, Egon Stahl, Springer International Student Edition	Unit/s (4.1,4.2,4.3)

PRACTICALS

SEMESTER V

ANALYTICAL CHEMISTRY

COURSE CODE: USCHP13 **CREDITS: 02**

1. Spectrophotometric estimation of fluoride
2. Estimation of magnesium content in Talcum powder by complexometry, using standardized solution of EDTA
3. Determination of COD of water sample.
4. To determine potassium content of a Fertilizer by Flame Photometry (Calibration curve method).
5. To determine the amount of persulphate in the given sample solution by back titration with standard Fe (II) ammonium sulphate solution.
6. To determine the amount of sulphate in given water sample turbidimetrically.

Note: Calculation of percent error is expected for all the experiments.

REFERENCES

1.	Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn., G. H. Jeffery, J Bassett, J Memdham and R C Denney, ELBS with Longmann (1989).
2.	Vogel's Textbook of Quantitative Chemical analysis, Sixth edition, J.Mendham et.al

SEMESTER VI

ANALYTICAL CHEMISTRY

COURSE CODE: USCH604 CREDITS: 02 LECTURES: 60

UNIT I: ELECTRO ANALYTICAL TECHNIQUES(3 & 6 UNITS)			
1.1	**Polarography** (**Numerical and word problems are expected)**		**11L**
	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	
1.2	**Amperometric Titrations**		**04L**
	1.2.1	Principle, Rotating Platinum Electrode(Construction, advantages and limitations)	
	1.2.2	Titration curves with example	
	1.2.3	Advantages and limitations	

UNIT II: METHODS OF SEPARATION - II (3 & 6 UNITS)			
2.1	**Gas Chromatography** (**Numerical and word problems are expected**)		**09 L**
	2.1.1	Introduction, Principle, Theory and terms involved	
	2.1.2	Instrumentation: Block diagram and components,types of columns, stationary phases in GSC and GLC, Detectors: TCD, FID, ECD	
	2.1.3	Qualitative, Quantitative analysis and applications	
	2.1.4	Comparison between GSC and GLC	
2.2	**Ion Exchange Chromatography**		**06 L**
	2.2.1	Introduction, Principle.	
	2.2.2	Types of Ion Exchangers , Ideal properties of resin	
	2.2.3	Ion Exchange equilibria and mechanism, selectivity coefficient and separation factor Factors affecting separation of ions	
	2.2.4	Ion exchange capacity and its determination for cation and anion exchangers.	
	2.2.5	Applications of Ion Exchange Chromatography with reference to Preparation of demineralised water, Separation of amino acids	
UNIT III:FOOD AND COSMETICS ANALYSIS(6 UNITS)			
3.1	**Introduction to food chemistry**		**10 L**
	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 and sodium benzoate by HPLC.	
	3.1.3	Study and analysis of food products and detection of adulterants **1)** Milk: Composition & nutrients, types of milk (fat free, organic and lactose milk) Analysis of milk for lactose by Lane Eynon's Method	

		2) Honey: Composition Analysis of reducing sugars in honey by Coles Ferricyanide method **3)** Tea: Composition, types (green tea and mixed tea) Analysis of Tannin by Lowenthal's method **4)** Coffee: Constituents and composition, Role of Chicory Analysis of caffeine by Bailey Andrew method	
3.2	**Cosmetics**		**05 L**
	3.2.1	Introduction and sensory properties	
	3.2.2	Study of cosmetic products – **1)** Face powder: Composition Estimation of calcium and magnesium by complexometric titration **2)** Lipstick: Constituents Ash analysis for water soluble salts: borates, carbonates and zinc oxide **3)** Deodorants and Antiperspirants: Constituents, properties Estimation of zinc by gravimetry	
UNIT IV:THERMAL METHODS AND ANALYTICAL METHOD VALIDATION (6 UNITS)			
4.1	**Thermal Methods**		**12 L**
	4.1.1	Introduction to various thermal methods (TGA, DTA and Thermometric titration)	

	4.1.2	**Thermogravimetric Analysis(TGA)** Instrumentation-block diagram,thermobalance (Basic components: balance, furnace, temperature measurement and control, recorder) Thermogram (TG curve)for$CaC_2O_4.H_2O$ and $CuSO_4.5H_2O$ 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	**Differential Thermal Analysis (DTA):** Principle**,** Instrumentation, and Reference material used	
		Differential thermogram (DTA curve) $CaC_2O_4.H_2O$ and $CuSO_4.5H_2O$	
		Applications Comparison between TGA and DTA.	
	4.1.4	**Thermometric Titrations –** Principle and Instrumentation Thermometric titrations of : 1) HCl v/s NaOH 2) Boric acid v/s NaOH 3) Mixture of Ca^{+2} and Mg^{+2} v/s EDTA 4) Zn^{+2} with Disodium Tartarate**.**	
4.2	**Analytical Method Validation**		**03L**
	4.2.1	Introduction and need for validation of a method	
	4.2.2	Validation Parameters: Specificity, Selectivity, Precision, Linearity, Accuracy and Robustness	

Note: Concept of sensitivity is to be discussed for all techniques and instruments mentioned in the syllabus.

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 (2.1,2.2)
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 (1.1,1.2,1.3)
9.	Food Analysis, Edited by S. Suzanne Nielsen, Springer	Unit/s (3.1,3.2)
10.	Food Analysis: Theory and practice, YeshajahuPomeranz, Clifton E. Meloan, Springer	Unit/s (3.1,3.2)
11.	Formulation and Function of cosmetics, Sa Jellineck	Unit/s (3.1,3.2)
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)
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 (3.1,3.2)
15.	High Performance Thin Layer Chromatography in Food analysis, by Prem kumar, CBS Publisher and distributer	Unit/s (3.1,3.2)
16.	Instrumental methods Of Analysis, by Willard Merritt Dean, 7thEdition, CBS Publisher and distribution Pvt Ltd	Unit/s (1.1,1.2,1.3) (4.1,4.2,4.3)
17.	Introduction to Polarography and Allied Techniques, By Kamala Zutshi, New Age International, 2006.	Unit/s (1.1,1.2,1.3)
18.	Modern cosmetics, E. Thomessen Wiley Inter science	Unit/s (3.1,3.2)

19.	Principles of Instrumental Analysis , 5th Edition, By Skoog, Holler, Nieman	Unit/s (4.1,4.2,4.3)
20.	Principles of Polarography by Jaroslav Heyrovský , Jaroslav Kůta, 1st Edition, Academic Press, eBook ISBN: 978148326478	Unit/s (1.1,1.2,1.3)
21.	Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969	Unit/s (2.1,2.2,)

PRACTICALS

SEMESTER VI

ANALYTICAL CHEMISTRY

COURSE CODE: USCHP14 **CREDITS: 02**

1 Estimation of Chromium in water sample spectrophotometrically by using Diphenyl carbazide.

2 Estimation of reducing sugar in honey by Willstatter method.

3 Estimation o Mg^{+2} & Zn^{+2} by anion exchange resin.
using an anion exchange resin

4 Estimation of acetic acid in Vinegar sample by using Quinhydrone electrode potentiometrically.

5 Determination of phosphoric acid in cola sample pH metrically.

Note: Calculation of percent error is expected for all the experiments.

References:

1.	Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn., G. H. Jeffery, J Bassett, J Memdham 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