Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS)
PUNE

Syllabus

for

S. Y. B. Sc. (Chemistry)

[Pattern 2019]

(B.Sc. Semester-III and Semester-IV)

From Academic Year

2020-2021

Deccan Education Society's
Fergusson College (Autonomous), Pune

S. Y. B. Sc. Chemistry (Pattern 2019)

From academic year 2020-2021

Particulars	Name of Paper	Paper Code	Title of Paper	No. of Credits
S. Y. B. Sc. Semester III	Theory Paper - 1	CHE 2301	Physical Chemistry	2
	Theory Paper - 2	CHE 2302	Organic Chemistry	2
	Practical Paper - 1	CHE 2303	Chemistry Practical - III	2
S.Y. B.Sc. Semester IV	Theory Paper - 3	CHE 2401	Inorganic Chemistry	2
	Theory Paper - 4	CHE 2402	Analytical Chemistry	2
	Practical Paper - 2	CHE 2403	Chemistry Practical - IV	2

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Physical Chemistry (CHE 2301)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall and describe the basic terms involved in thermodynamics, chemical kinetics. State the Nernst distribution law and modify the law based on association and dissociation of solute in solvent.	
CO2	Interpret vapour pressure-composition, temperature-composition diagram of ideal and non-ideal solutions. Evaluate the molecular weight of organic liquids using steam distillation.	
CO3	Solve the numerical based on thermodynamics, chemical kinetics and distribution law.	
CO4	Explain different laws of thermodynamics and analyze different thermodynamic equations.	
CO5	Determine the spontaneity of chemical reaction in terms of entropy, Gibb's free energy and relate the K_p and K_c.	
CO6	Devise integrated rate expressions for zero order, first order, second order and third order reactions and give examples. Write the different theories and reaction rates.	

Unit No.	Title of Unit and Contents	No of Lectures
I	**Chemical Kinetics** Introduction to Chemical kinetics, molecularity and order of reaction, reaction rates, rate laws, rate constant and its significance, Integrated rate law expression and its characteristics - zero order, first order, second order equal and unequal initial concentrations, differential rate laws for half-integral order reactions, pseudo molecular reactions, factors affecting rate of reaction, determination of order of reaction, collision theory of reaction rates (Arrhenius equation and non-Arrhenius behavior), transition state theory, numerical.	**9**
II	**Distribution Law** Nernst distribution law, Statement and thermodynamic proof for Nernst distribution law, Limitation of distribution law, association and dissociation of solute in solvent (modification in distribution law), application of distribution law, Numerical	**3**
III	**Chemical Thermodynamics** Thermodynamic Terms: System, Boundary, Surroundings, Homogenous and heterogeneous systems, Types of thermodynamic systems, Intensive and extensive properties, States of systems (equilibrium and non-equilibrium states), Thermodynamic process, Reversible and irreversible process, Nature of heat and work, Internal energy, First law of thermodynamics, Carnot cycle, enthalpy of system, molar heat capacities, Adiabatic expansion of an ideal gas,	**8**

	work done in Adiabatic reversible expansion Second law of thermodynamics: spontaneous process, entropy, standard entropy of formation,	
IV	**Free Energy and Equilibrium** Introduction, Helmholtz free energy, variation of Helmholtz free energy with volume and temperature, Helmholtz free change energy for chemical reaction, Gibb's free energy, Variation of Gibb's free energy with pressure and temperature, Gibb's free energy change for chemical reaction, Free energy change for physical transitions, Free energy change for an ideal gas; standard free energy change, Gibb's-Helmholtz equation, Properties and significance of Gibb's free change, Van't Hoff reaction isotherm, thermodynamic equilibrium constants, Relation between Kp and Kc for gaseous reactions, variation of equilibrium constant with temperature, Criteria for chemical equilibrium, Physical equilibrium, Clapeyron equation, Clausius–Clapeyron equation, Application of Clausius - Clapeyron equation, numericals.	**8**
V	**Solutions** Ways of expressing concentration, Solutions of gases in gases, Henry law, Solution of liquids in liquid , Types of solutions, Ideal solutions, Raoult's law, ideal and non-ideal solutions, Henry's law, Application of Henry's law with example CS_2 in acetone, problems based on Raoult's law and Henry's law, vapor pressure–composition diagram of ideal and non-ideal solution, temperature composition diagram of miscible binary solutions, distillation from temperature–composition diagram, Azeotropes, Theory of fractional distillation, steam distillation, solutions of solids in liquid.	**8**

Learning Resources:

1. Principles of Physical Chemistry. By Maron and Pruton 4th Ed. Oxford & IBH.
2. Essentials of Physical Chemistry. By Bahl and Tuli, Reprint edition 2014.
3. Fundamentals of Analytical Chemistry by Skoog, West, Holler and Crouch.

Reference Books:

1. Elements of Chemical thermodynamics, L.K Nash 2nd Ed.
2. Chemical Thermodynamics by M. Roy.
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa, 2004.
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson, 2013.
5. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Organic Chemistry (CHE: 2302)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe basic concepts and reaction mechanisms of organic chemistry. Identify the reagents, isomers, types of organic compounds and their nomenclature.	
CO2	Explain the mechanisms of organic reactions. Classify the organic compounds based on stereo chemical aspects. Predict the products and sensitivity of reagents in organic reactions.	
CO3	Apply basic concepts to classify organic compounds, explain their transformations and write the reaction sequence.	
CO4	Analyze the chemical reactions and their significance. Explain the effect of the stereo chemical factors and reaction conditions on rate of reactions. Differentiate between reaction intermediates involved in organic synthesis.	
CO5	Justify the given condition for organic reactions and determine the organic structure.	
CO6	Rearrange the organic compound in given conformation and configuration.	

Unit No.	Title of Unit and Contents	No of Lectures
I	**Stereoisomerism** Recapitulation of Stereochemistry in general, Baeyer's strain theory, Conformation and stability of cyclohexane, mono and di-substituted cyclohexane with CH_3 groups. Locking of conformation.	**5**
II	**Reaction Mechanism** Introduction to reaction intermediates: carbocation, carbanion, carbene, nitrene and free radicals. Reaction mechanism of Aliphatic nucleophilic substitution (S_N1, $S_N2$and S_{Ni} reactions) and Elimination (E1, E2 and E1cB, Saytzeff and Hoffmann elimination) reactions and factors affecting their rate of reaction. E2-elimination reactions in substituted cyclohexane (cis and trans 1-bromo-2-methyl cyclohexane). Competitive studies between substitution and elimination reactions.	**5**
III	**Introduction of Bio-Molecules** **Carbohydrates:** Definition, classification, configuration of (+) Glucose (D/L, d/l, R/S), Fischer-Haworth and chair formulae, epimers, anomers, mutarotation, Killiani-Fischer synthesis and Ruff degradation. **Reaction of monosaccharide (glucose):** oxidation, reduction, osazone and ester formation. Brief account of disaccharides (structure only): Sucrose, cellobiose, maltose and lactose. **Amino acids:** Fischer projection, relative configuration, classification, structures, Zwitterion, Isoelectric point. **Preparation of Amino Acids:** Strecker synthesis, Gabriel's	**7**

	phthalimide synthesis, amination of a-halo acids, Reductive Amination, Reactions of Amino acids: esterification, acetylation, peptide bond synthesis, reaction with Dansyl chloride, $HNO_3$and ninhydrin test.	
IV	**Reagents in Organic Synthesis** **Reducing agents:** Catalytic hydrogenation (homogenous and heterogeneous), Birch reduction, Bouvaelt-Blanc Reduction, $NaBH_4$, $LiAlH_4$, Sn/HCl, NH_2NH_2/OH. **Oxidizing agents:** $KMnO_4$, $K_2Cr_2O_7$, Jones reagent, PDC, PCC, Per acids, OsO_4, Prevost oxidation, MnO_2 andSeO_2.	**5**
V	**Chemistry of Heterocyclic Compounds with One Hetero Atom** Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Nitration, Sulphonation, Acylation and Catalytical reduction.	**6**
VI	**Name Reactions and Rearrangements (with mechanism)** Name reactions: Reimer–Tiemann, Kolbe's–Schmidt, Wittig, Wittig Horner, Perkin, Cannizzaro, Knoevenagel and Reformatsky reaction, Aldol, Claisen and Benzoin condensation. Rearrangements: Pinacol-Pinacolone, Beckmann and Baeyer Villiger oxidation, Hofmann bromamide degradation, Curtius and Fries rearrangement.	**8**

Learning Resources:

1. Organic Chemistry by Stanley Pine McGraw-Hill Book Company 5th edition.
2. Organic Chemistry by Morrison Boyd &Bhattacharjee Pearson Education 7th Ed.

Reference Books:

1. Organic Chemistry by Paula Bruice Pearson Higher Education 7th edition.
2. Organic Chemistry by Clayden, Greeves, Oxford press.
3. Reactions, rearrangements and reagents - S N Sanyal.
4. Heterocyclic Chemistry by Joule and Keith Mills, Wiley-Blackwell 4th edition
5. Biochemistry by Satyanaryana Elsevier 4th edition
6. Organic Chemistry - 7th Ed. Morrison, Boyd & Bhattacharjee Pearson Education, 2011
7. Outline of Biochemistry 5th Ed., Conn, Stumpf Bruening & Roy Doi John Wiley 1987
8. Stereochemistry of carbon compounds - E. L. Eliel
9. Heterocyclic Chemistry 5th Ed. John A. Joule and Keith Mills, Wiley-Blackwell 2010
10. Reactions, rearrangements and reagents - S N Sanyal

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Physical & Organic Chemistry Practical (CHE2303)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify the type of organic compounds. Recall the procedure, list the apparatus and chemicals and represent the assembly.	
CO2	Carry out and examine the given experiment by using different techniques.	
CO3	Analyze the experimental yield, physical, thermodynamic properties using different methods and compare the observations with standard values.	
CO4	Validate Nernst's distribution law and measure the rate constant by applying chemical kinetics.	
CO5	Justify the given condition for organic reactions and measure the yield of each step.	
CO6	Plan the procedure according to the experimental conditions.	

List of practicals (Compulsory 10 + 2 Activity)

Sr No.	List of practicals
	A. Physical Chemistry Practicals (Any Five)
1	To determine critical solution temperature of phenol water system.
2	To determine molecular weight of given organic liquid by steam distillation.
3	Determination of solubility of benzoic acid at different temperature and to determine ΔH of dissociation process.
4	To determine the partition coefficient of iodine between water and carbon tetrachloride.
5	To study and compare the hydrolysis of an ester using HCl and H_2SO_4 catalyst
6	To study the neutralization of acid (HCl) by base (NaOH) and CH_3COOH by NaOH.
7	Determination of enthalpy of hydration of copper sulphate.
	B. Organic Chemistry Practicals (Any Five)
1	Qualitative analysis of unknown binary organic compounds. (**Any four**) Solid-Solid mixtures only **(Including elemental test)**
2	Organic Preparation. (**Any one)** (**Including Crystallization, MP, TLC**) Preparation of phthalimide form phthalic anhydride, Benzolyationofoneofthefollowingamines(aniline,*o*-,*m*-,*p*-toluidinesando-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol,p-cresol) Preparation of Glucosazone from D-glucose, Preparation of 2:4- DNP derivative of aldehyde or ketone.

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Inorganic Chemistry (CHE: 2401)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall s,p,d block elements and different terms in coordination chemistry.	
CO2	Interpret elements according to their physical properties, acids and bases according to different theories.	
CO3	Solve numerical problems related to 18 electron rule and magnetic properties of complexes. Apply different theories to coordination complexes.	
CO4	Compare strength of different acids and bases. Discuss anomalous behaviour of elements and physical properties of elements with electronic configuration.	
CO5	Evaluate colour, magnetic property of d block elements and complexes, molecular structure of Xenon compounds, different types of isomers.	
CO6	Design different molecular structures of complexes, s,p block elements formed molecules on the basis of hybridisation, valence bond theory,	

Unit No.	Title of Unit and Contents	No of Lectures
I	**Acids, Bases and Solvents:** Different theories of acids – bases: Arrhenius theory, Bronsted-Lowry concept, solvated proton, conjugate acid – base pairs, relative strength of acids and bases - trends of hydracids and oxyacids, Pauling's rules, levelling and differentiating solvents, Lewis acid-base concept, classification of Lewis acids and bases and their relative strength, Lux-Flood theory, Properties of solvents.	**6**
II	**Chemistry of *s* and *p* Block Elements:** Position of elements in the periodic table, electronic configuration, trends in properties like atomic size, ionization potential, electro-negativity, electron affinity, relative stability of different oxidation states, Inert pair effect, anomalous behavior of first member of each group. Differences of Li and Be from other members of their groups (the diagonal relationship). Compounds of s-block elements: oxides, hydroxides, peroxides, super oxides. Compounds of Gr – I, Gr – II ions with Crown ether and Cryptands, separation of s-block elements using crown ethers. **Chemistry of Boron** – Electron deficient nature of hydrides, halides (BH_3, BX_3) and their polymerisation. Structure and bonding of diborane and tetraborane (2e-3c bonds). Boric acid and borates, Borazine, Boron nitrides, Borax - properties and structure. **Chemistry of Carbon and Silicon** - Allotropy and catenation. Intercalation compounds e.g., Graphite Intercalation compounds (GIC), CNT (Carbon Nanotube), graphenes and fullerenes. Properties, structure and uses of silanes, silicates, silicones and	**16**

	siloxanes. **Chemistry of Nitrogen and Phosphorous** - The presence of lone pair and basicity of trivalent compounds; hydrides and oxides of N and P; Phosphazene, phosphonitrilic acid $(PNCl_2)_{n.}$ d– orbital participation in P-compounds. **Chemistry of Sulphur** - Oxides, oxyacids, poly sulphides – properties and structure; S-N compounds $(SN)_x$; d–orbital participation in S-Compounds. **Chemistry of Halogen** – Color of Halogens in different medium, hydrides, their acidity; inter-halogen compounds; polyhalide ions, pseudohalogens, cationic compounds of iodine -– properties and structure.	
III	**Coordination Chemistry** Werner's theory – the primary, secondary valency, valence bond theory (inner and outer orbital complexes), electroneutrality principle, back bonding, Sidgwick's theory, EAN Rule, Basic terms and IUPAC Nomenclature of coordination compounds (excluding the polynuclear ones), Isomerism, Types of Isomers (Structural isomerism and Stereoisomerism).	**6**
IV	**Chemistry of d-Block Elements:** Position of d-block in the periodic table, General group trends with special reference to electronic configuration, size of atoms and ions, variable oxidation states, catalytic properties, complex formation ability, colour, magnetic properties.	**4**
V	**Noble Gases:** Occurrence and uses, rationalization of inertness of noble gases, Clathrates, Preparantion properties and molecular structure of xenon fluorides (XeF_2, XeF_4 and XeF_6), oxides and oxofluorides (VSEPR Theory). Nature of bonding in noble gas compounds (VB and MO treatment for XeF_2 and XeF_4).	**4**

Learning Resources:

1.Concise Inorganic Chemistry by J. D. Lee - 5thedition.

2. Coordination Chemistry2009D. Banerjea

References:

1) Inorganic Chemistry, D.F. Shiver & P.W. Atkins- C. H. Longford ELBS - 2ndedition.
2) Basic Inorganic Chemistry, F.A. Cotton and G. Wilkinson, Wiley Eastern Ltd 1992.
3) Inorganic Chemistry – J D Lee
4) Concept and Model of Inorganic Chemistry by Douglas – Mc Daniels - 3rdedition.
5) Chemistry by Raymond Chang - 5thedition.
6) Inorganic Chemistry by A. G. Sharpe - 3rd edition.
7) Fundamental Chemistry by A. K. Dee.(3rdEd.)
8) Advanced Inorganic Chemistry, Satyaprakash, Tuli, Basu.
9) Text book of Inorganic Chemistry, P. L. Soni.

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Analytical Chemistry (CHE: 2402)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Define the terms of analytical chemistry and its applications in different areas. Explain accuracy, precision, different terms to express concentrations of the solution.	
CO2	Explain different methods of quantitative analysis of organic compounds and determine empirical formula or molecular formula by knowing composition of elements derived from those methods. Illustrate the role of the common ion effect and solubility product in inorganic qualitative analysis.	
CO3	Identify and describe errors in quantitative analysis, solve computations, and analyse the reliability of results. Prepare standard solutions, calibrate volumetric glass wares, identify interfering anions, perform its removal, separate basic radicals from mixture and perform detection of acidic radicals.	
CO4	Classify compounds with different functional groups, errors in quantitative chemical analysis and minimize errors. Discuss types of instrumental and non-instrumental analysis.	
CO5	Select different tests for detection of elements by Lassigen's test, and characteristic tests for different functional groups. Explain principle behind non-instrumental - titrimetric analysis, interpret neutralization curves for different acid base titration and articulate the types along with role of indicators.	
CO6	Select group reagent, precipitating agents for different cations, anions and a suitable indicator for titration. Calculate solubility product and concentration of ion/solution.	

Unit No.	Title of Unit and Contents	No of Lectures
I	**Introduction to Analytical Chemistry** Introduction, chemical analysis, applications of chemical analysis, sampling, types of analysis, common techniques, instrumental methods, other techniques, factors affecting on choice of method.	**2**
II	**Errors in Quantitative Analysis** Introduction, Error, accuracy, precision, methods of expressing accuracy and precision, classification of errors, significant figures and computations, distribution of random errors, mean and standard deviations, reliability of results, numerical.	**4**
III	**Inorganic Qualitative Analysis** Basic principle, common ion effect, solubility, solubility product, preparation of original solution, classification of basic radicals in groups, separation of basic radicals, removal of interfering anions (phosphate and borate), detection of acidic radicals.	**7**

IV	**Qualitative & Quantitative Analysis of Organic Compounds** **Qualitative Analysis**: Types of organic compounds, reactions of different functional groups, analysis of binary mixtures. **Quantitative Analysis**: Analysis–estimation of C, H, (O) by combustion tube, detection of nitrogen, sulfur, halogen and phosphorous by Lassigen's test, estimation of nitrogen by Dumas's Kjeldahl's method, estimation of halogen, sulphur and phosphorus by Carius Method, determination of empirical and molecular formula, numerical problems.	**8**
V	**Non-Instrumental Volumetric Analysis** Introduction of volumetric (titrimetric) analysis, titrant, titrand, direct titration, indirect titration-back and blank titration Introduction, methods of expressing concentrations, primary and secondary standard solutions, Apparatus used and their calibration: burettes, micro burettes, volumetric pipettes, graduated pipettes, volumetric flask, methods of calibration, Instrumental & non-instrumental analysis, principles & types **Acid–Base Titrations** Acid base indicators, Ostwald's Theory of acid base indicators, mixed and universal indicators Strong acid–Strong base, Weak acid–strong base, Weak Acid-Weak base titration, Displacement titrations, polybasic acid titrations. (Discuss titration with respect to neutralization and equivalence point determination, titration curves and limitations) **Redox Titrations** Principle of redox titration, detection of equivalence point using suitable indicators, Titration of oxalic acid vs $KMnO_4$, Application-Estimation of Fe (II) & H_2O_2 **Complexometric Titrations** Principle, Mg-EDTA titration, Role of Metal ion indicators in EDTA titration, choice of indicators, Applications, Estimation of Al (III) & Nickel. **Iodometric Titration: Iodometry (Direct and Indirect Titration)** Principle, detection of end point, difference between iodometry and iodimetry, Standardization of sodium thiosulphate solution using potassium dichromate and iodine method, Applications, estimation of Cu.	**15**

Learning Resources:

1) Fundamentals of Analytical Chemistry by Skoog, West, Holler and Crouch
2) A textbook of macro & semi micro qualitative analysis by A.J. Vogel, fifth edition
3) Quantitative Organic Analysis, fourth edition, A.J. Vogel, ELBS
4) Vogel's textbook of Quantitative Analysis, sixth edition J. Mendham, R.C. Denney, J.D. Barnes, and MJK Thomas
5) Analytical Chemistry by G.D. Christian, 6th Edition.
6) Vogel's Textbook of Quantitative Analysis, 6th Edition J. Mendham, R. C. Denney, J. D. Barnes, and MJK Thomas

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Inorganic & Analytical Chemistry Practical (CHE 2403)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	List all primary standard substances, indicators required for standardization, titration, acidic and basic radicals along with physical properties.	
CO2	Prepare a standard solution and standardization process. Distinguish dry tests of acidic and basic radicals.	
CO3	Perform titrimetric analysis by using theoretical knowledge, confirmatory tests for acidic and basic radical.	
CO4	Distinguish between back and blank titration. Apply common ion effects and solubility principle.	
CO5	Determine amount of analytes using titrimetric analysis and identify the best indicator for given acid base titration. Estimate error, accuracy, precision using absolute error and relative error methods. Judge a procedure for phosphate and borate removal.	
CO6	Calculate and minimize error by taking constant burette reading and standardization of given secondary standard solution for given titration. Build a complete analysis of binary inorganic mixture.	

List of practicals (Compulsory 10 + 2 Activity)

Any ten experiments from the list of experiments

Sr No.	List of practicals
	A. Inorganic Qualitative Analysis (Any Four)
1	Two simple mixtures (without phosphate or borate)
2	Three Mixtures containing $(PO_4)^{3-}$ (With (PO_4^{3-}) removal)
3	Three Mixtures containing $(BO_3)^{3-}$ (With$(^{BO}3^{3-})$ removal)
	Preparation of Coordination Complexes and Yield (Anyone)
1	Preparation of $[Cu(NH_3)_4]SO_4.H_2O$
2	Preparation of $[Ni(NH3)_6]Cl_2$
	B. Analytical Chemistry Practicals (Any Five)
1	Determination of Ca in presence of Mg using EDTA.
2	a) Preparation of standard 0.05N oxalic acid solution and standardization of approx 0.05N KMnO4 solution. b) Determination of the strength of given H2O2 solution with standard 0.05N KMnO4solution.
3	a) To determine the amount of Aspirin from a given tablet. b) To finds the absolute error & relative error with reference to the mean of analysis. c) To find the standard deviation & relative standard deviation with reference to the mean of analysis.
4	Estimation of Nickel/Aluminum from the given salt solution by using Eriochrome Black-T indicator (Back titration method).
5	To determine the amount of copper from the given solution iodometrically.

6	a) To choose the best indicator in the titration between standard 0.05N oxalic acid solution & approx. 0.05N NaOH. b) To standardize the approx. 0.05N NaOH solution against standard 0.05N oxalic acid solution using best indicator. c) To determine the amount of acetic acid in commercial vinegar by titrating with approx. 0.05N NaOH solution using selected best indicator.
7	To find out the amount of Acetone in the given solution iodometrically.
8	Report of one day industrial study tour [either in semester III or IV].