Deccan Education Society's

Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum

for 3/4 years B**.** Sc. / B. Sc. (Honours) Programme

as per guidelines of

NEP-2020

for

F. Y. B. Sc. (Chemistry)

With effect from Academic Year

2023-2024

Program Outcomes (POs) for B. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of an graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**ical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**l competence:** Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic Competence:** i. Understand the fundamental concepts of theoretical and experimental aspects of physical, organic, inorganic, analytical and allied chemistry subjects. ii. Explain and clarify the understanding of thermodynamic, spectroscopic, kinetic and quantum models, stereochemistry and mechanism of organic reactions, chemical bonding and structure elucidation, analytical techniques and solving numerical problems. iii. Correlate and apply the theoretical chemistry knowledge in explaining practical schemes
PSO2	**Personal and Professional Competence:** i. Solve numerical problems, mechanisms, analytical interpretation using chemistry concepts and knowledge. ii. Execute the knowledge of spectroscopic techniques learnt to characterize and identify structures of molecules used in drugs and pharmaceutical products. iii. Analyse chemical species qualitatively and quantitatively using appropriate analytical techniques. iv. Build confidence, patience, time management, leadership and intangible skills to achieve the goals in competitive examinations for higher learning courses in chemistry to meet global competencies.
PSO3	**Research Competence:** i. Identify and understand research literature and appropriate techniques used in chemistry related problems. ii. Create awareness and promote research attitudes among students. iii. Interpret spectroscopic data to identify basic organic compounds.
PSO4	**Entrepreneurial and Social Competence:** i. Understand and explain the processes needed in domain related industries and write their general aspects. ii. Apply information related to material safety data sheets (MSDS) needed in various industries. iii. Embrace reduce, recycle and restore chemicals (3R's) approach and gain the sense of ethical, social and environmental awareness and responsibility.

Fergusson College (Autonomous), Pune
Proposed First Year Curriculum as per NEP 2020

Department of Chemistry

Structure for Major / Minor

Semester	Paper Code	Paper Title	Type	Credits
I	**CHE-100 (Major)**	Organic and Inorganic Qualitative Analysis I	**Practical**	**2**
	CHE-101 (Major)	Introduction to Chemistry	**Theory**	**4**
	CHE-120 (GE/OE)	Chemistry of Food	**Theory**	**2**
	CHE-121 (GE/OE)	Chemistry in daily life	**Theory**	**2**
	CHE-130 (VSC)	Industrial Skills for Chemists-I	**Voc. Skill**	**2**
	CHE-140 (SEC)	Good Laboratory Practices and Methods	**Skill**	**2**
	IKS-101 (IKS)	Indian Knowledge Systems	**IKS**	**2**
II	**CHE-150 (Major)**	Physical and Analytical Chemistry Experiments I	**Practical**	**2**
	CHE-151 (Major)	Fundamentals of Chemistry	**Theory**	**4**
	CHE-161 (Minor)	General Chemistry	**Theory**	**2**
	CHE-170 (GE/OE)	Chemistry of Perfumes	**Theory**	**2**
	CHE-171 (GE/OE)	Basics of Forensic Science	**Theory**	**2**
	CHE-180 (VSC)	Industrial Skills for Chemists-II	**Voc. Skill**	**2**
	CHE-190 (SEC)	Basic Analytical Skills-I	**Skill**	**2**

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory / Practical	No. of Hours per Week Theory / Practical	Maximum Marks	CE 40 %	ESE 60%
1	**15 / 30**	**1 / 2**	**25**	**10**	**15**
2	**30 / 60**	**2 / 4**	**50**	**20**	**30**
3	**45 / 90**	**3 / 6**	**75**	**30**	**45**
4	**60 / 120**	**4 / 8**	**100**	**40**	**60**

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

F. Y. B. Sc. Semester I		
CHE-100	**Organic and Inorganic Qualitative Analysis I (Major-Practical)**	**Credits:** 2 **Hours:** 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Analyse and verify the mixture of cations and anions	
CO2	Determine the nature, functional groups and physical constant of organic compounds	
CO3	Identify and separate the mixture of organic compounds based on thin layer chromatography	
CO4	Purify organic compounds by recrystallization and sublimation method.	

Expt. Type	Title of the Experiment
I	Laboratory Safety
II	**Organic Chemistry Practicals [Any FIVE]** (a) Purification of Organic Compound by Crystallization Method by using different solvents (two compounds), Distillation (Demonstration), Sublimation Method (one compound) (b) Qualitative analysis / characterization of organic compound containing C, H, (O), N, S elements (no element test), (c) Separation of a mixture of ortho and para nitrophenol OR ortho and para nitroaniline by thin layer chromatography (TLC) (d) Use of software for drawing chemical structures of molecules.
III	**Inorganic Chemistry Practicals [Any FIVE]** **Mixtures without Phosphate & Borate]** (a) Semi-micro inorganic qualitative analysis of binary mixture containing two cations and two anions.

References:

1. Khosla, B.D.; Garg, V. C. and Gulati Senior practical physical chemistry, R. Chand &Co.:New Delhi, 2011.
2. Garland, C. W.; Nibler, J.W. and shoemaker, D. P Experiments in physical chemistry 8thEd. McGraw-Hill: New work, 2003.
3. Mendham, J., A. I. Vogel's Qualitative Organic Chemical Analysis 6th Ed., Pearson, 2009.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education, 2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry,5th Ed., Pearson, 2012.
6. Vogel's Qualitative Inorganic Analysis 7th Edn, Revised by G Svehla, Pearson 2009.

	F. Y. B. Sc. Semester I	
CHE-101	**Introduction to Chemistry (Major- Theory)**	**Credits:** 4 **Hours:** 60
	Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Recall and outline the fundamental concepts of atomic structure,distribution law and modify the law based on association and dissociation of solute in solvent.	
CO2	Discuss atomic model and interpret atomic spectrum. Explain the concept of wave-particle duality and wave equation, quantum numbers and rules of orbital electron distribution	
CO3	Apply mathematics for chemistry using graphical representation, differentiation, integration and solve numerical problems based on chemical mathematics, atomic structure, and distribution law	
CO4	Develop structure-reactivity relationship.	
CO5	Compare theories of chemical bonding and classify the types of hybridization and explain geometries of molecules.	
CO6	Design suitable synthesis route of organic compound.	

Unit	Content	No. of hours
I	**Chemical Mathematics:** Scientificnotation, powers and roots, Logarithms, graphical presentation of functions, differential calculus, Integral calculus.	**6**
II	**Atomic Structure:** Rutherford atomic model, electromagnetic spectrum, Bohr's theory, its limitations and atomic spectrum of hydrogen atom, de Broglie equation, Heisenberg's Uncertainty, Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2, quantum numbers and their significance, normalized and orthogonal wave functions, sign of wave functions, Radial and angular wave functions for hydrogen atom, radial and angular distribution curves, shapes of *s*, *p*, *d* and *f* orbitals.	**10**
III	**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, numericals.	**4**
IV	**Chemical Bonding:** Electronic theory of valence, attainment of stable configuration, Types of bonds – ionic, covalent, coordinate, metallic bonds - qualitative idea. Types of overlaps: s-s, s-p, p-p, p-d, d-d and their examples, Ionic bond: General characteristics, types of ions, size effects, radius ratio rule (CN 2, 3, 4) and its limitations. Covalent bond: Lewis structure, Valence Bond Theory (Heitler-London approach). Pauling-Slater Theory. Concept of hybridization, equivalent and non-equivalent hybrid orbitals. Types of hybridization involving s, p, & d orbitals, hybridization geometries in the molecules like i) BeF2 ii) BF3 iii) [MnCl4]2- iv) [Ni(CN)4]2-v) Fe(CO)5 vi) [Cr(H2O)6]2+, vii) IF7, Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs	**10**

	and bond pairs of electrons: H2O, NH3, PCl5, PCl6-, SF6, SO42-, ClF3, Cl2O, BrF5, I3-, BrF2+, TeCl4, XeO3.	
V	**Periodicity of Elements:** Long form of periodic table, *s, p, d, f* block elements, Classification of elements, electronic configuration, Pauli's Exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, variation of orbital energy with atomic number, detailed discussion of the following properties of the elements with reference to *s* and *p*-block, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, Atomic and ionic radii, Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Applications of ionization enthalpy, Electron gain enthalpy (Electron affinity) and trends in groups and periods, Electro-negativity, Pauling's scale. Variation of electro-negativity with bond order and hybridization.	**10**
VI	**Structural effects and reactivity of organic compounds:** Organic Compounds: Covalent bond, hybridization, shapes of molecules, influence of hybridization on bond properties, inter and intramolecular hydrogen bonding, Electronic Displacements: Inductive, resonance and mesomeric effects hyper conjugation, tautomerism and their applications, dipole moment, organic acids and bases, their relative strength, strength of acids and bases, pKa and pKb values of common organic acids and bases, Homolytic and heterolytic fission with suitable examples, curly arrow rules, formal charges; electrophiles and nucleophiles nucleophlicity and basicity, types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism, addition, elimination, substitution.	**10**
VII	**Chemistry of Aliphatic and Aromatic Hydrocarbons :**Introduction to Hydrocarbons, Classification of hydrocarbons. **Alkanes**: IUPAC nomenclature, formation of alkanes, Wurtz reaction, Wurtz-Fittig reactions, free radical substitutions: Halogenation-relative reactivity and selectivity. **Alkenes**: IUPAC nomenclature, synthesis of alkenes, mechanism of E1, E2, E1cb reactions Saytzeff and Hofmann eliminations **Reactions of alkenes:** Electrophilic additions reactions and their mechanisms: Markownikoff/Anti Markownikoff addition, oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction, syn and anti-hydroxylation, 1,2/1, 4 addition reactions in conjugated dienes, Diels-Alder reaction, allylic and benzylic bromination and mechanism, e.g.propene, 1-butene, toluene,ethylbenzene and their industrial applications. **Alkynes:** IUPAC nomenclature, acidity, electrophilic and nucleophilic additions, hydration to form carbonyl compounds, alkylation of terminal alkynes.	**10**

References:

1. Principles of PhysicalChemistry by Maron and Prutton, 1992
2. Mortimer, R. G. Physical Chemistry 3rd Ed. elsevier: NOIDA, UP, 200.
3. Chemistry The Central Science 14 th Ed. Person
4. Mathematics in Chemistry by Sourav Pal and K V Raman 2004

5. Physical Chemistry: A Molecular Approach by Donald A. McQuarrie and John D. Simon.

F. Y. B. Sc. Semester I		
CHE-120	**Chemistry of Food (GE/OE-Theory)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Label the basic parts of digestive organs and recall their functions. Remember the food regulation laws. Define terminologies related to nutrition	
CO2	Classify nutrients, toxins, and adulterants. Compare and contrast its features. Justify the advantages and disadvantages of food additives.	
CO3	Apply the principles of ancient and modern foodpreparation and preservation techniques and its utility in retaining the nutritive value of various types of food.	
CO4	Analyse the nutrients. Interpret the results of qualitative and quantitative analysisof components in food.	
CO5	Explain the scope and significance of nutrition. Discuss the effect of food additives on human body	
CO6	Plan suitable methodologies and reagents for qualitative, quantitative analysis of nutrients, toxins and adulterants in food. Design healthy alternatives to meet the daily recommended intake of nutrients.	

Unit	Content	No. of hours
I	**Types of Nutrients:** Basic concept on Food and Nutrition. Scope of Nutrition, Classification of food. Types of Macro and Micronutrients. Sources and significance. Recommended daily intake. Structure and functions of the digestive system. Process of digestion and absorption of food. Significance of digestive juices in digestion.	**07**
II	**Food Adulterants and Healthy choices:** Types of Food toxins. Food adulteration in various daily food items. Healthy alternatives.	**08**
III	**Food preservation methods:** Definition, objectives, and principles of food preservation. Different ancient and modern methods of food preservation to retain nutritive value.	**08**
IV	**Food analysis and Food regulation laws:**Identification and analysis of macro and micronutrients in food. Weight for age, height for age, weight for height, body Mass Index (BMI) Waist - Hip Ratio, (WHR). Skin fold thickness. Simple home testing of food adulterants. National and International Food Adulteration prevention laws. Reading of food label and ingredients.	**07**

References:

1. SrilakshmiB (2017): Nutrition Science,6th MulticolourEd. New Age International (P) Ltd.

2. Mann J and TruswellS(2017) : Essentials of Human Nutrition, 5th Ed. Oxford University Press.
3. Handbook of Food and Nutrition- Dr.M.Swaminathan,Bangalore Press
4. Sadasivan S and ManikamK(2007): Biochemical Methods, 3rd Ed. New Age International (P)Ltd.
5. GopalanC , Rama Sastri BV and Balasubramanian SC(2016): Nutritive value of Indian Foods,
Indian Council of Medical Research.
6. Subalakshmi, G and Udipi, SA(2006):Food processing and preservation, 1st Ed. New Age International (P)Ltd.

	F. Y. B. Sc. Semester I	
CHE-121	**Chemistry in daily life (GE/OE-Theory)**	**Credits:** 2 **Hours:** 30
	Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Define chemical terms of commercial items used in daily life and its features.	
CO2	Classify oils,soaps,detergents, food additives and polymers.	
CO3	Apply the basic concepts of chemistry in understanding the components of commercial products used in daily life and its significance.	
CO4	Analyse food additives in various food products.	
CO5	Explain the principles and procedures involved in the manufacturing process of daily use products.	
CO6	Design simple procedures for preparation of commonly used products in everyday life.	

Unit	Content	No. of hours
I	**Oils and fats**: Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils. Halphen test.	**6**
II	**Soaps & Detergents**: Definition, classification, manufacturing of soaps and detergents, composition and uses	**6**
III	**Food additives**, adulterants, and contaminants- Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate. Artificial food colorants: Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.	**10**
IV	**Fibers and polymers**: natural fibers, cotton, wool, silk, rayon, artificial fibers,polyamides, acrylic acid, PVC, PVA; Experiments: Synthesis of polymers,soaps,detergents,sanitizers	**8**

References:

1.Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley, 1994.
2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, elsevier, 2008.
3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman, 2008.
4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) Bioinorganic Chemistry. University Science Books (1994)
5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.
6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International

F. Y. B. Sc. Semester I		
CHE-130	**Industrial Skills for Chemists-I (VSC)**	**Credits:** 2 **Hours:** 30
	Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	List the various instruments used in electronics laboratories.	
CO2	Understand the operating principle of each instrument	
CO3	Illustrate the functions of front panel control of the instrument	
CO4	Know the accessories required for operations of the instruments	
CO5	Learn how to operate the instrument	
CO6	Develop practical skills in using electronic instruments for measurement	

Unit	Content	No. of hours
I	Introduction to various chemical industries, requirements to become an industrial chemist, technical knowledge, and industrial chemist Skills. technology, mathematics, communication, Problem-solving, Analytical, Attention to details, Critical thinking, Teamwork, Interpersonal, Leadership, Legal and regulatory knowledge, Multitasking, Laboratory safety knowledge, Personal Protective Equipment (PPE), Interprofessional skills.	**8**
II	Strategies for Development of analytical Skills. Choice of suitable heating and cooling methods. Choice of suitable concentrations. Safe handling of syringes and needles. Safe use of vacuum lines and gas cylinders Safe handling of cryogenic liquids and solids. Correct use and care of balances.	**6**
III	Choice of appropriate glassware, including required precision, use of pipettes, burettes, preparation of ppm, molar, volume percent, and mass/volume solutions, dilution of solutions, methods for solution filtration	**8**
IV	Introduction of toiletries industry, statistics, market and data facts, Synthesis of different types of soaps, shampoos and sanitizers.	**8**

References:

1. https://nationalcareers.service.gov.uk/job-profiles/chemist
2. Chemistry Department Faculty Publication Series
3. https://www.degruyter.com/document/doi/10.1515/pac-2018-0718/pdf
4. https://www.degruyter.com/document/doi/10.1515/ci-2021-0302/pdf
5. Vogel textbook of chemical quantitative analysis, Longman Scientific
6. Chemistry Practical, O. P. Pandey, D.N. Bajpai, S. Giri, S. Chand

F. Y. B. Sc. Semester I		
CHE-140	**Good Laboratory Practices and Methods (SEC)**	**Credits:** 2 **Hours:** 30
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Outline and understand the principles of chemical toxicology and safety in laboratory.	
CO2	Interpret the safety data sheets to categorise chemicals according to their hazards.	
CO3	Classify, illustrate and implement the methods to manage hazards.	
CO4	Compare and integrate the methods to handle chemical waste	
CO5	Apprise the safety measures and apply to chemical waste management.	
CO6	Identify, modify and construct a plan for safe laboratory operations (SOP) and laboratory waste management.	

Unit	Content	No. of hours
I	**Principles, Ethics and Practices** Introduction to Good lab practice (GLP) History, Scope, fundamental Points of GLP, Four Principles of safety-RAMP, Hazards in different Labs, The Student Safety Ethics, Safety rules, Role as a Student, Critical analysis of Lab incidents (include reactions). Standard Operating Procedures (SOP) in the laboratory. GLP compliance and preparation for certification: ISO/ ICE 17025 and laboratory accreditation, Quality control lab and Quality assurance	**6**
II	**Understanding and Communicating Laboratory Hazards** Potential pathways of exposure and blocking these pathways to prevent exposure, Hazard recognition through the basics of understanding label, signs, symbols, terms, and other sources of information, Safe handling and interpreting the material safety data sheet (MSDS), overview of GHS Safety Data Sheets and GHS labelling.	**8**

III	**Laboratory Hazards and responses** **Chemical Hazards**: corrosive acids, bases, gases, oxidizers, flammables, fire triangle, water reactive compounds, pyrophoric chemicals and reactions, peroxides, cryogens. **Radiation Hazards**: ionizing, nonionizing radiations and electric and magnetic field. **Biological Hazards:** and Biosafety - hazards of biological agents and some general approaches to prevent exposures. **Introduction to Toxicology**: Basic principles of toxicology, Factors Influence Toxicity, Acute and Chronic Toxicity, Mercury toxicity, Carcinogens, Mutagens. **Responses**: chemical spills (acids, bases and other chemicals) and fire, classes of fires and types of fire extinguishers. First aid in chemical lab, emergency safety equipment. **Demonstration**: Fire extinguisher	**10**
IV	**Handling chemicals and Minimizing hazards in laboratory** Introduction to handling hazardous chemical waste, storingflammable and corrosive liquids, maintaining a safe and secure laboratory, managing chemicals in the laboratory. Safety measures for common laboratory operations. Managing risk- decision about safety, eye and face, skin protection- clothes, gloves and tools, chemical hoods, contamination and ventilation, safety measures for common laboratory operations, radiation, laser and biological safety cabinets. Lab waste management, Green Chemistry alternatives to conventional methods in labs and industries, The Twelve Principles of Green Chemistry and Sustainability.	**6**

References:

1. Laboratory safety for chemistry students, second edition, Robert H. Hill, Jr.David C. Finster, John Wiley & Sons.
2. Handbook of Good laboratory practice (GLP),UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) https://fctc.who.int/publications/i/item/handbook-good-laboratory-practice-%28-glp%29
3. Solid Waste Management, Principles and Practice, RameshaChandrappa, DigantaBhusan Das, Springer.
4. Production-Integrated Environmental Protection and Waste Management in the Chemical Industry, Claus Christ, WILEY-VCH.
5. Fundamentals of Industrial Safety and Health Dr. K.U. Mistry, Siddharth Prakashan.
6. Hazardous waste management rules-2016, 1st editon, Ministry of environment, forest & climate change, govt. of India

F. Y. B. Sc. Semester I		
IKS-101	**Indian Knowledge Systems (IKS)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Understand traditional Indian knowledge systems and their relevance to electronic	
CO2	Understand the historical and cultural context of Indian knowledge systems	
CO3	Explore the practical applications of Indian knowledge systems in electronics	
CO4	Develop critical thinking and problem-solving skills in the context of Indian knowledge systems and electronics	

Unit	Contents	No. of hours
I	**Overview of IKS** • Survey of IKS Domains: A broad overview of disciplines included in the IKS, and historical developments. • Sources of IKS knowledge, classification of IKS texts, a survey of available primary texts, translated primary texts, and secondary resource materials. Differences between sutra, bhashya, karika, and vartika texts. Fourteen/eighteen vidyasthanas, tantrayukti • Vocabulary of IKS: Introduction to Panchamahabhutas, concept of a sutra, introduction to the concepts of non-translatables (Ex. dharma, punya, aatma, karma, yagna, shakti, varna, jaati, moksha,loka, daana, itihaasa, puraana etc.) and importance of using the proper terminology. Terms such as praja. janata, loktantra, prajatantra, ganatantra, swariva, surajya, rashtra, desh. • Philosophical foundations of IKS: Introduction to Samkhya, vaisheshikaand Nyaya • Methods in IKS: Introduction to the concept of building and testing hypothesis using the methods of tantrayukti. Introduction to pramanas and their validity, upapatti; Standards of argumentation in the vada traditions (introduction to concepts of vaada, samvaada, vivaada, jalpa, vitanda). Concept of poorvapaksha, uttarapaksha.	**15**
II	**Case Studies (Few of these may be selected as appropriate)** • Mathematics of Madhava, NilakanthaSomayaji • Astronomical models of Aryabhata • Wootz steel, Aranumula Mirrors, and lost wax process for bronze castings • Foundational aspects of Ayurveda • Foundational aspects of Ashtanga yoga • Foundational aspects of Sangeeta and Natva Shastra • Discipline Specific Case Study	**10**
III	**India and the World:** Influence of IKS on the world, knowledge exchanges with other classical civilizations. and inter-civilizational exchanges	**5**

References:

1. An Introduction to Indian Knowledge Systems: Concepts and Applications, B Mahadevan, V R Bhat, and Nagendra Pavana R N; 2022 (Prentice Hall of India).
2. Indian Knowledge Systems: Vol I and I, Kapil Kapoor and A K Singh; 2005 (D.K. Print World Ltd).
3. The Beautiful Tree: Indigenous India Education in the Eighteenth Century. Dharampal, Biblia Impex, New Delhi, 1983. Reprinted by Keerthi Publishing House Pvt Ltd. Combatore, 1995.
4. Indian Science and Technology ni the Eighteenth Century, Dharampal. Delhi: Impex India, 1971. The British Journal for the History of Science.
5. The Wonder That Was India, Arthur Llewellyn Basham, 1954, Sidgwick& Jackson.
6. The India they saw series (foreigner visitors on India ni history from 5CE to 17th century), Ed. Meenakshi Jain and Sandhya Jain, Prabhat Prakashan

F. Y. B. Sc. Semester II		
CHE-150	**Physical and Analytical Chemistry Experiments I (Major- Practical)**	**Credits: 2 Hours: 60**
	Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	List different glass apparatus and identify the correct volumetric glass apparatus required for experiment.	
CO2	Compare viscosity of different liquids.	
CO3	Apply gravimetric method to find the percentage composition of inorganic compounds	
CO4	Explain and determine heat of solution by measuring the temperature change of solvent during the addition of solute.	
CO5	Measure the pH of solution and evaluate dissociation constant of weak acid and rate constant of acid catalysed ester hydrolysis. Calculate the values of molar gas constants (R) in different units using Eudiometric method.	
CO6	Devise an appropriate titrimetric method to determine strength of different solution.	

Expt. Type	**Content**	**Practical (hrs)**
I	**Physical Chemistry Practicals (Any FIVE)**: • Polar plots of s, p orbitals. • Relative viscosity of given organic liquids by viscometer. • Molar gas constants (R)in different units by eudiometric method. • Dissociation constant of a weak acid by pH metry. • To determine molecular weight of solute by depression in freezing point method. Naphthalene – Sulphur. • To determine molecular weight of given electrolyte (KCl) and on-electrolyte (Urea) by Landberger's method and to study abnormal molecular weight of electrolyte. • Scientific graphing of following functions using MSExcel. Exponential, logarithmic, linear Determination of rate constant of	**5**

	acid catalyzed ester hydrolysis. • Heat of solution of potassium nitrate in water.	
II	**Analytical Chemistry Practicals (Any FIVE):** • Cleaning and Maintenance of apparatus and instruments. • Calibration of apparatus: Burette, Pipette, Volumetric flask, Thermometers (1/10th, 110^0C and 360^0C). • Preparation standard solution of 0.05N oxalic acid(exact) and standardization and determination of strength of given 0.05N (approx) KMnO4 solution. • Determination of acetic acid in vinegar by titrimetric method. • Determination of percentage composition of ZnO and $ZnCO_3$ in the given mixture gravimetrically. • Estimation of hydroxide/sulphate and carbonate present together in mixture. • Estimation of Fe(II) by using standardized 0.05N (approx) KMnO4 solution. Estimation of the amount of Mg (II) present in the given solution complexometrically.	**5**

References:

1. Khosla, B.D., Garg, V. C. and Gulati Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2011.
2. Garland, C. W. Nibler, J.W. and Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed. McGrawHill, New York, 2003.
3. Mendham, J., Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2008.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education,2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson, 2012.

F.Y.B.Sc. Semester II		
CHE- 151	**Fundamentals of Chemistry (Major-Theory)**	**Credits:** 4 **Hours:** 60
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Recall and outline the development in kinetic theory gas equation and states of matter.	
CO2	Understand terms to derive kinetic gas equation and study the effect of parameters on properties of matter.	
CO3	Derive gas equations and design methods to find velocities of gases. Balance redox reaction in acidic and basic condition	
	Identify oxidation/reduction change in reaction and solve the problems based on equivalent weight of oxidants, reductants and apply rules to assign Oxidation number	
CO4	Apply mole concept to measure the concentrations of solutions and solve the problems based on acid base titration.	
CO5	Visualise and draw different stereochemical projections of organic molecules to determine configuration and predict chirality.	
CO6	Classify aromatic molecules and predict their reactivity towards electrophiles and nucleophiles.	

Unit	Content	No. of hours
I	**Gaseous State:** Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behavior, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants, and their calculation from van der Waals equation. Andrew's isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules.	**10**
II	**Liquid State:** Intermolecular forces, physical properties of liquids- vapour pressure, surface tension and coefficient of viscosity and their determination, cleansing action of detergents, effect of temperature on physical properties, liquid crystals.	**5**
III	**Solid State:** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, point and space groups, seven crystal systems and Bravais lattices, X-ray diffraction, Bragg's law, Relation between radius and edge, packing fraction and density of crystal.	**5**
IV	**Mole Concept:** GMV relationship, problems based on mole concept, methods of expressing concentrations, strength, normality, molarity, molality, %w/v, %v/v, ppm, standardization of solutions, primary and secondary standard substances, preparation of standard solution of acids and bases, problems related to acid base titration. Principles involved in volumetric analysis (from practical experiments) to be carried out.	**7**
V	**Oxidation and Reduction:** Definitions of related terms, oxidizing and Reducing agents, Oxidation number, Rules to assign oxidation number. Balancing redox reactions by ion-electron method (both acidic and alkaline medium), Problem based on equivalent weight of oxidants and reductants. Standard Electrode Potential and its application to redox reactions.	**8**
VI	**Metallic bonding and Weak chemical forces:** Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators. Weak Chemical Forces: vander Waals, ion-dipole, dipole-dipole, induced dipole, dipole induced dipole interactions, Lennard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.	**5**

VII	**Stereochemistry:** Introduction to isomerism and its classification. Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions. Conformational isomerism in alkanes (Ethane, propane and n-butane) with energy profile diagrams, Geometrical isomerism Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules, Optical isomerism: Optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, diastereoisomers, meso structures, racemic mixture and resolution, relative and absolute configuration, D/L, R/S and E/Z designations.	**10**
	Aromatic Hydrocarbons: Aromaticity: Hückel's rule, anti aromatic, non aromatic, homoaromatic, pseudoaromatic, mono and bicyclic aromatic hydrocarbons. Electrophilic aromatic substitution of benzene, naphthalene: sulphonation, nitration, halogenation, Friedel Craft alkylation/acylation reactions, with their mechanism, Directing effects of the groups. Industrial application of aromatic hydrocarbons. Aromatic Nucleophilic Substitution reactions. Benzyne intermediate.	**10**

References:

1. Principles of Physical Chemistry by Maron and Prutton, 1992
2. Clayden, J., Greeves, N., & Warren, S. G. (2012). Organic chemistry. Oxford: Oxford University Press, 2012.
3. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, (Pearson Education), 1992.
4. Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2007.
8. Bodie Douglas and DarlMcdaniel Concepts and Model of Inorganic Chemistry Third Edition, Wiley, 1994.
9. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press, 2002.
10. Donald A. Tarr, Gary Miessler Inorganic Chemistry Third Edition, Pearson, 2013.
11. F. Albert Cotton and Geoffrey Wilkinson Advanced Inorganic Chemistry, Sixth Edition, 1962.
12. Sarin and Sarin Numerical Problems in Chemistry, 1980.

F.Y.B.Sc. Semester II		
CHE-161	**General Chemistry (Minor-Theory)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall basic concepts of states of matter and electronic effects operating in organic molecules.	
CO2	Explain the mechanisms of organic reactions and classify the organic compounds based on their nomenclature and their basic properties	
CO3	Calculate the charge on given chemical species and solve numerical problems based on states of matter	

CO4	Explain and elaborate fundamental laws of crystal structure, identify, and draw seven crystal systems. Explain Bragg's equation and analyze X-ray diffraction of the crystal system.
CO5	Review the properties of liquids with respect to intermolecular force and compare theories of chemical bonding and hybridization/ geometries of molecules
CO6	Develop the relation between trend and the chemical properties of compounds.

Unit	Content	No. of hours
I	**Liquid State:** Intermolecular forces, physical properties of liquids-vapour pressure, surface tension and coefficient of viscosity and their determination, cleansing action of detergents, effect of temperature on physical properties, liquid crystals.	**5**
II	**Solid State:** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, point and space groups, seven crystal systems and Bravais lattices, X-ray diffraction, Bragg's law, Relation between radius and edge, packing fraction and density of crystal.	**5**
III	**Chemical Bonding:** Electronic theory of valence, attainment of stable configuration, Types of bonds – ionic, covalent, coordinate, metallic bonds - qualitative idea. Types of overlaps: s-s, s-p, p-p, p-d, d-d and their examples, Ionic bond: General characteristics, types of ions, size effects, radius ratio rule (CN 2, 3, 4) and its limitations. Covalent bond: Lewis structure, Valence Bond Theory (Heitler-London approach). Pauling-Slater Theory. Concept of hybridization, equivalent and non-equivalent hybrid orbitals. Types of hybridization involving s, p, & d orbitals, hybridization geometries in the molecules like i) BeF2 ii) BF3 iii) [MnCl4]2- iv) [Ni(CN)4]2-v) Fe(CO)5 vi) [Cr(H2O)6]2+, vii) IF7, Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H2O, NH3, PCl5, PCl6-, SF6, SO42-, ClF3, Cl2O, BrF5, I3-, BrF2+, TeCl4, XeO3.	**10**
IV	**Structural effects and reactivity of organic compounds** Organic Compounds: Covalent bond, hybridization, shapes of molecules, influence of hybridization on bond properties, inter and intramolecular hydrogen bonding, Electronic Displacements: Inductive, resonance and mesomeric effects, hyper conjugation, tautomerism and their applications, dipole moment, organic acids and bases, their relative strength, strength of acids and bases, pKa and pKb values of common organic acids and bases, Homolytic and heterolytic fission with suitable examples; electrophiles and nucleophiles, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism, addition, elimination, substitution, and rearrangement reactions.	**10**

References

1. Principles of PhysicalChemistry by Maron and Prutton, 1992.
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa, 2004.
3. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP, 200.
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson, 2013.
5. Essentials of physical chemistry Bhal, Tuli and S. Chand, 2010.
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7. Clayden, J., Greeves, N., & Warren, S. G. Organic chemistry. Oxford: Oxford University Press, 2012.
8. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, (Pearson Education), 1992.
9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 1964.
10. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
11. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2008.
12. Bodie Douglas and DarlMcdaniel Concepts and Model of Inorganic Chemistry Third Edition, Wiley, 1983.
13. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press 2002.
14. Donald A. Tarr, Gary Miessler Inorganic Chemistry Third Edition, Pearson, 2013.
15. F. Albert Cotton and Geoffrey Wilkinson Advanced Inorganic Chemistry, Sixth Edition2013.

F. Y. B. Sc. Semester II		
CHE-170	**Chemistry of Perfumes (GE/OE-Theory)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Define basic concepts of perfumes, formulation and its physiological effects.	
CO2	Apply basic concepts to extract perfumery chemicals using various methods.	
CO3	Distinguish between the natural identical and synthetic perfumery compounds.	
CO4	Identify the chemical process for the isolation of perfumes, flavours and alcohol.	
CO5	Develop the relationship between trend and the perfumery properties of compounds or their structure. Synthesise the given organic compound with a suitable route.	

Unit	**Content**	**No. of hours**
I	**Introduction to Perfumes:** History, classification of perfumes, the concept of aroma, types and physiological effects. Composition, formulation and working mechanism of perfume. Introduction to perfumery chemicals: Natural sources, natural identical and synthetic compounds.	**8**

II	**Extraction Methods:** Extraction methods of perfumery chemicals. Examples of some important perfumery chemicals (synthesis, properties and chemistry). Essential oils – Production equipment, distillation, Steam distillation, Flower oils – Extraction with alcoholic extracts, absolute of enflurages and chassis. Extraction with volatile solvents, selection of solvent and extraction apparatus. Extraction using Soxhlet Apparatus.	**12**
III	**Isolation Methods:** Isolates – Methods of Isolation, properties & uses of the following:Eugenol, Pinene, Linalool, Citral and Geraniol. Flavours – Sources and properties of Vanilla, Rose, Pineapple, Peppermint, Mango, Raspberry, Orange & Lemon. Alcohol - Manufacture of ethanol, Purification of Ethanol, Deodorization of ethanol.	**10**

References:

1. W. A. Poucher, Perfumes, Cosmetics and soaps, Ninth edition, – (Pages 3 to 67 and relevant pages from 68 to 360).
2. P. P. Sharma, Cosmetic Formulation, Manufacturing, and Quality Control. 3rd Edition, 1998) Vandana Publications, Lucknow, (relevant pages from 569 to 573).
3. Giriraj Prasad, Manufacture of Perfumes, Cosmetics & Detergents.
4. D. D. Wasule Perfumes: History & Chemistry Vol-I.
5. S.B. Srivastva, Perfume flowers & essential oil industries by
6. Earnest Guenther, "The Essential Oils" vol. I Robert E. Kreiger Publishing Co. Huntington, New York, 1972.
7. Paul Z. Bedoukian, "Perfumery and Flavouring Synthetics" II Edn, elsevier Publishing Co., Amsterdam, London, New York, 1967.
8. H. Panda, Perfumes and Flavours Technology Handbook, Asia Pacific Business Press Inc., 2010, Delhi
9. The Chemistry of Perfume: A Laboratory Course for Nonscience Majors. *J. Chem. Educ.* 2012, 89, 5, 613–619.

F. Y. B. Sc. Semester II		
CHE-171	**Basics of Forensic Science (GE/OE-Theory)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define the scope of forensic science and evidence in criminal laws.	
CO2	Discuss the uses of physical and biological evidence in criminal proceedings.	
CO3	Apply basic concepts to the detection of drugs, and serology of blood, semen, saliva, and DNA as evidence.	
CO4	Distinguish between physical evidence and biological evidence.	
CO5	Justify the physical and biological evidence in criminal proceedings.	
CO6	Propose steps for analyzing various samples obtained at crime scenes, develop critical thinking, and investigate stepwise.	

Unit	Content	No. of hours
I	**Introduction to Forensic Sciences** Scope of forensic science, evidence in criminal law (act, case studies).	**8**
II	**Physical Evidences** Identification, collection and preservation of sample. physical properties of sample material. Use of physical evidence (Fingerprint) and biological evidence (blood, semen, saliva and DNA) in criminal proceedings.	**12**
III	**Trace Evidences** Introduction, principle and analysis of trace evidence (hair, fibre and paints).	**10**

References:

1. Suzanne Bell, Forensic Chemistry, 1st edition, Person Education Ltd.
2. http://www.forensicsciencesimplified.org/..
3. B. B. Nanda and R. K. Tiwari, Forensic Science in India: A Vision for the Twenty-First Century, Select Publishers, New Delhi (2001).
4. M. K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002).
5. S. H. James and J. J. Nord, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).
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8. Sharma, B. R. (2019). Forensic Science in Criminal Investigation & Trails. Universal Law Publishing Company.
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F. Y. B. Sc. Semester II		
CHE-180	**Industrial Skills for Chemists-II (VSC)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define various terms standard solutions, practical yield specific rotation, refractive Index etc.	
CO2	Discuss the physical properties like solubility, crystallization, refractive index.	
CO3	Apply the chromatographic techniques in separation and identification of different compounds such as dyes and amino acids etc.	
CO4	Analyse and apply the methodology to synthesize small organic molecules.	
CO5	Learn the extraction of sugarcane juice for manufacturing sugar.	
CO6	Develop the skills for preparation of organic compounds and preparation of solutions.	

Unit	Content	No. of hours
I	**Chemical process industry**: Introduction, Overview and current status, Raw materials, manufacturing, industrial methods of synthesis of small organic molecules (Methanol, Formaldehyde and Formic acid etc), pharmaceuticals (Aspirin, Paracetamol, Ibuprofen, morphine), manufacturing and uses of ethylene, propene, branched and unbranched higher olefins)	**10**
II	**Preparation and analysis of industrially important products:** Preparation of $K_2Cr_2O_7$. To find out the concentration of unknown $K_2Cr_2O_7$ solution using $Na_2S_2O_3$ solution as an intermediate. Preparation of standard $KMnO_4$ and ferrous ammonium sulphate solution. To find out the strength of unknown ferrous ammonium sulphate solution using as an intermediate. Preparation of Aspirin and its analysis. Preparation of antacid. Synthesis and analysis of chemicals Determination of ascorbic acid in vitamin C tablets by iodometric or coulometric titrations. Identify and separate the sugars/ amino acids present in the given mixture by paper chromatography	**10**
III	**Introduction to sugar industry:** Manufacture and recovery of cane sugar from molasses, manufacture of sucrose from beet root, testing and estimation of sucrose, determination of the specific rotation of sucrose solution	**10**

References:

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2. The Advanced Physical Chemistry Practical Guide" by learned authors – Dr. Charu Arora and Dr. Sumantra.
3. http://www.chemguide.co.uk/analysis/chromatography/paper.html
4. https://doi.org/10.1016/C2013-0-05506-5
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8. Chemistry Practical, O. P. Pandey, D.N. Bajpai, S. Giri, S. Chand
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F. Y. B. Sc. Semester II		
CHE-190	**Basic Analytical Skills-I (SEC)**	**Credits:** 2 **Hours:** 30
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Define fundamental terms in analytical chemistry	
CO2	Understand calibration and sampling methods for quantitative analysis	
CO3	Apply analytical methods for sampling, titrations, separations and interpret the results for chemical analysis.	
CO4	Prepare solutions of different concentrations for different estimations.	
CO5	Communicate chemical knowledge effectively through written reports, oral presentations.	

Unit	Content	No. of hours
I	**Basics of analytical chemistry:** Volumetric analysis, Gravimetric analysis, Volumetric apparatus: uses and calibration.	**5**
II	**Laboratory solution preparation:** basic concept of preparation of solution, preparation of simple inorganic salt solutions, preparation of acid and base solutions, recipes for biological, histological and chemical solutions. Preparation of indicators (Starch, methyl orange, phenolphthalein, eriochrome black T) , buffers.	**13**
III	**Methods ofseparation in chemistry:** filtration, centrifugation, decantation, precipitation, dialysis, separating funnel, distillation, chromatography.	**12**

References:

1. Fundamentals of Analytical Chemistry; Skoog, West. Holler and Crouch 9th edition; Mary Finch. (2014).
2. Principles of Instrumental Methods of Analysis; Skoog, Holler and Nieman, 5 th edition, Saunders College Publishing, International Limited (1999).
3. Analytical Chemistry; Gary D Christian; 6th edition; John Wiley and Sons (2010).
4. Modern Analytical Chemistry; David Harvey; McGraw Hill Higher education publishers, (2000).
5. Analytical Chemistry Principles; John H Kennnedy, 2nd edition, Published by Cengage Delmar Learning India Pvt (2011).
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