Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum

for F. Y. B. Sc. Chemistry

With effect from June 2019

Programme Structure

Year	SEM	Course Code	Course Title	Credits
F. Y. B. Sc.	I	CHE1101	Chemical Mathematics & Atomic Structure	2
		CHE1102	Basics of Organic Chemistry & Periodicity of Elements	2
		CHE1103	Chemistry Practical - I	2
	II	CHE1201	Ionic Equilibrium & Chemical Bonding	2
		CHE1202	Stereochemistry, Hydrocarbons & Mole Concept	2
		CHE1203	Chemistry Practical - II	2
S. Y. B. Sc.	III	CHE2301	Chemical Kinetics and Quantitative Analysis of Organic Compounds	3
		CHE2302	Reaction Mechanism and Principles of Metallurgy	3
		CHE2303	Inorganic and Analytical Chemistry Practicals	2
	IV	CHE2401	Thermodynamics and Volumetric Analysis	3
		CHE2402	Introduction of Biomolecules and Coordination Chemistry	3
		CHE2403	Physical and Organic Chemistry Practicals	2
T. Y. B. Sc.	V	CHE3501	Physical Chemistry I	3
		CHE3502	Inorganic Chemistry I	3
		CHE3503	Organic Chemistry I	3
		CHE3504	Analytical Chemistry I	3
		CHE3505	Nuclear Chemistry I	3
	V	**OR**		
		CHE3506	Biochemistry I	3
		CHE3507	Industrial Chemistry I	3
		CHE3511	Physical Practicals I	2
		CHE3512	Inorganic Practicals I	2
		CHE3513	Organic Practicals I	2

T. Y. B. Sc.	VI	CHE3601	Physical Chemistry I	3
		CHE3602	Inorganic Chemistry I	3
		CHE3603	Organic Chemistry I	3
		CHE3604	Analytical Chemistry I	3
		CHE3605	Nuclear Chemistry I	3
			OR	
		CHE3606	Biochemistry I	3
		CHE3607	Industrial Chemistry I	3
		CHE3611	Physical Practicals I	2
		CHE3612	Inorganic Practicals I	2
		CHE3613	Organic Practicals I	2

Programme Learning Outcomes

PO1	Acquire coherent understanding of fundamental concepts in chemistry to integrate inter-disciplinary science subjects.
PO2	Acquire communication skills to effectively transmit the acquired information in written and oral formats.
PO3	Gain the sense of ethical, social and environmental awareness and responsibility.
PO4	Acquire basic computer knowledge for computation and interpretations of scientific data.
PO5	Demonstrate rational thinking to design experimental protocols to analyze and solve the issues of agriculture, pharmaceutical, food, cosmetic, environmental monitoring industries etc.
PO6	Acquire confidence, patience, time management, leadership and intangible skills to achieve the goals.
PO7	Demonstrate appropriate laboratory and instrumentation skills to design, conduct and interpret experimental outcomes with scientific, analytic reasoning.
PO8	Practice safe laboratory methods to curtail the chemical hazards.
PO9	Embrace reduce, recycle and restore chemicals (3R's) approach.
PO10	Undertake competitive examinations for higher learning courses in chemistry to meet global competencies.

Class: F. Y. B. Sc.
Course code: CHE1101
Title: Chemical Mathematics & Atomic Structure

Course Outcomes	**Suggested Pedagogical Processes**
1. Understand the significance of logarithm and learn and apply the plotting of graph, derivatives and integration in chemical studies. 2. Understand the basic concepts of states of matter, gas laws, kinetic gas equation, ideal and non- ideal gases and Van der Waals equation to study the behavior of gases. 3. Understand the factors affecting the different physical properties of liquid such as vapour pressure, surface tension and viscosity 4. Know the classical and quantum mechanical approach to understand the atomic structure.	1. Problem solving sessions on logarithm, integration, differentiation. 2. Discussion of different types of graph using laboratory examples. 3. Use of ICT tools. 4. Use of diagram charts, models 5. Quiz and seminar 6. Demonstration of apparatus (Viscometer, Stalagmometer) 7. Lecture method and models. 8. Problem solving sessions.

UNIT I	**Chemical Mathematics** 1.1. Logarithm - Rules of logarithm, Characteristic and mantissa, Change of sign and base, Problems based on pH and pOH. Graphical representation of Equations-Rules for drawing graph co-ordinates etc., Equation of straight line, slope and intercept, plotting the graph from the data of chemical properties and problems. 1.2.Derivative - Rules of differentiation and partial differentiation, Algebraic, logarithmic and exponential functions and problems. 1.3.Integration- Rules of integration, Algebraic and exponential functions and problems.	**6 Lectures**
UNIT II	**Gaseous State** 2.1 Kinetic molecular model of a gas, postulates and derivation of the kinetic gas equation, collision frequency, collision diameter; mean free path, Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy. 2.2 Law of equipartition of energy, degrees of freedom and molecular basis of heat capacities, Behaviour of real gases, Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases, Causes of deviation from ideal gas behaviour, 2.3 van der Waals equation of state, its derivation, van der Waals equation expressed in virial form and calculation of Boyle temperature. 2.4 Isotherms of real gases and their comparison with van der Waals	**12 Lectures**

	isotherms.	
UNIT III	**Liquid State** 3.1 Qualitative treatment of the structure of the liquid state, physical properties of liquids, vapour pressure, surface tension and coefficient of viscosity and their determination, Effect of addition of various solutes on the surface tension and viscosity. 3.2 Explanation of cleansing action of detergents, temperature variation of viscosity of liquids and comparison with that of gases, qualitative discussion of structure of water.	**6 Lectures**
UNIT IV	**Atomic Structure** 4.1 Rutherford atomic model, electromagnetic spectrum, Bohr's theory, its limitations and atomic spectrum of hydrogen atom, de Broglie equation, Heisenberg's Uncertainty. 4.2 Principle and its significance, Schrödinger's wave equation (derivation not required), significance of ψ and ψ^2, quantum numbers and their significance, normalized and orthogonal wave functions, sign of wave functions. 4.3 Radial and angular wave functions for hydrogen atom, radial and angular distribution curves, shapes of *s*, *p*, *d* and *f* orbitals, Pauli's Exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, variation of orbital energy with atomic number.	**12 Lectures**

Learning Resources

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.
6. J.D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2008.
7. Bodie Douglas and DarlMcdanielConcepts and Models of Inorganic Chemistry Third Edition, Wiley, 1983.
8. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press, 2002.
9. Donald A. Tarr, Gary Miessler Inorganic Chemistry Third Edition, Pearson, 2013.
10. A. Bahl, B. S. Bahl, and G.D. Tuli, Essentials of Physical Chemistry, S. Chand and Co Pvt Ltd 2014. (pages 1-96 for Atomic Structure)

Course code: CHE1102
Title: Basics of Organic Chemistry & Periodicity of Elements

Course Learning Outcome	**Suggested Pedagogical Processes**
1. Understand the basic concepts of the organic chemistry including covalent bonding and properties, organic acid-base and factors affecting strength of acids and bases. 2. Understand the mechanism of reactions with alkanes, alkenes and alkynes. 3. Understand the trend in the periodic table with reference to atomic and ionic size, electron gain enthalpy, ionization enthalpy. 4. Understand the effect of nuclear charge on shielding and screening effect in atoms.	1. Lecture method and 3D models. 2. Use of ICT tools. 3. Quiz and seminar. 4. Mind mapping techniques and concept charts. 5. Problem solvingsessions.

UNIT I	**Basics of Organic Chemistry** 1.1 Organic Compounds: Covalent bond, hybridization, shapes of molecules, influence of hybridization on bond properties, inter and intra molecular hydrogen bonding. 1.2 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, pK_a and pK_b values of common organic acids and bases. 1.3 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 and rearrangement reactions.	**13 Lectures**
UNIT II	**Chemistry of Hydrocarbons** 2.1 Introduction to Hydrocarbons, Classification of hydrocarbons (up to aromatic hydrocarbons). 2.2 Alkanes: IUPAC nomenclature, formation of alkanes, Wurtz reaction, Wurtz-Fittig reactions, free radical substitutions: Halogenation-relative reactivity and selectivity. 2.3 Alkenes: IUPAC nomenclature, formation of alkenes by elimination reactions, mechanism of E1, E2, E1cb reactions, Saytzeff and Hofmann eliminations, Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation), 1, 2 and 1, 4	**9 Lectures**

	addition reactions in conjugated dienes, Diels-Alder reaction, allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene and their industrial application of hydrocarbons. 2.4 Alkynes: IUPAC nomenclature, acidity, electrophilic and nucleophilic additions, hydration to form carbonyl compounds, alkylation of terminal alkynes.	
UNIT III	**Research in India in the field of Chemistry** 3.1 Introduction to Premier Indian Research Institutes in Chemistry, ShantiswaroopBhatnagar awardees in last 5 years in Chemistry.	**2 Lectures**
UNIT IV	**Periodicity of Elements** 4.1 Long form of periodic table, *s*, *p*, *d*, *f* block elements, Classification of elements, electronic configuration, detailed discussion of the following properties of the elements with reference to *s* and *p*-block. 4.2 Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. 4.3 Atomic and ionic radii. 4.4 Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Applications of ionization enthalpy. 4.5 Electron gain enthalpy (Electron affinity) and trends in groups and periods. 4.6 Electro-negativity, Pauling's scale. Variation of electro-negativity with bond order and hybridization.	**12 Lectures**

Learning resources

1. Clayden, J., Greeves, N., & Warren, S. G. *Organic chemistry*. Oxford: Oxford University Press, 2012.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, (Pearson Education), 1992.
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 1964.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2007.
6. Bodie Douglas and DarlMcdaniel Concepts and Models of Inorganic Chemistry Third Edition, Wiley,1994.
7. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press, 2002.
8. Donald A. Tarr, Gary Messler Inorganic Chemistry Third Edition, Pearson, 2013.
9. F. Albert Cotton and Geoffrey Wilkinson Advanced Inorganic Chemistry, Sixth Edition, 2013.

Course code: CHE1103
Title: Chemistry Practical - I

Course Learning Outcome	Suggested Pedagogical Processes
1. Acquire the skills for qualitative analysis of organic, inorganic compounds and the purification techniques. 2. Apply safe laboratory practices, skillfulness and self-confidence in the lab.	1. Demonstration of experiments. 2. Use of ICT tools. 3. Quiz and seminar. 4. Practice sessions.

UNIT I	**Laboratory Safety**	**1 Practical**
UNIT II	**Organic Chemistry Practicals** 1.1 Purification of Organic Compound by 1.1.1 Crystallization Method by using different solvents (two compounds) 1.1.2 Distillation (Demonstration) 1.1.3 Sublimation Method (one compound) 1.2 Qualitative analysis / characterization of organic compound containing C, H, (O), N, S elements (no element test) 1.3 Separation of a mixture of ortho and para nitrophenol OR ortho and para nitroaniline by thin layer chromatography (TLC). 1.4 Use of ChemDraw Software	**5 Practicals**
UNIT III	**Inorganic Chemistry Practicals [Any FIVE Mixtures without Phosphate & Borate]** 2.1 Semi-micro inorganic qualitative analysis of binary mixture containing two cations and two anions.	**5 Practicals**

Learning Resources:

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. 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.

Course code: CHE1201
Title: Ionic Equilibrium & Chemical Bonding

Course Learning Outcome	**Suggested Pedagogical Processes**
1. Understand the crystal structures with the help of various parameters. 2. Understand the theories of strong eletrolytes, factors influencing degree of dissociation and application of solubility product and ionic product in qualitative analysis. 3. Apply the colligative properties: lowering of vapour pressure, elevation of boiling point and depression in freezing pointto determine the molecular mass. 4. Understand the fundamental concepts and theories of bondingand their application to justify the shape and geometry of inorganic molecules.	1. Discussion of different types of graph using laboratory examples. 2. Lecture method and models. 3. Use of ICT tools. 4. Use of diagram charts, models. 5. Quiz and seminar. 6. Demonstration of apparatus (Landsberger's apparatus). 7. Problem solving sessions.

UNIT I	**Solid State** 1.1 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. 1.2 Qualitative idea of point and space groups, seven crystal systems and Bravais lattices, X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. 1.3 Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Relation between radius and edge, packing fraction and density of crystal.	**10 Lectures**
UNIT II	**Ionic Equilibrium** 2.1 Ostwald dilution law, verification, limitations. Theory of strong electrolyte, Debye-Huckel theory, degree of dissociation, common ion effect, factors which influence degree of dissociation. 2.2 Solubility equilibria, solubility product and ionic product and its application in qualitative analysis.	**6 Lectures**
UNIT III	**Theory of dilute solutions: Colligative Properties** 3.1 Colligative properties, lowering of vapour pressure, measurement of lowering of Vapour pressure, boiling point elevation, measurement of elevation of boiling point by Landsberger 's method, depression in freezing point method, Beckmann's method, Osmotic Pressure.	**8 Lectures**

	3.2 Application of colligative properties to determine molecular weight of non-electrolyte, abnormal molecular weight, Relation between Vant Hoff's factor and degree of dissociation of electrolyte by colligative property and numerical.	
UNIT IV	**Chemical Bonding** 4.1 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. 4.2 Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation. Born-Haber cycle and its application, solvation energy. 4.3 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) BeF_2 ii) BF_3 iii) $[MnCl_4]^{2-}$ iv) $[Ni(CN)_4]^{2-}$v) $Fe(CO)_5$ vi) $[Cr(H_2O)_6]^{2+}$, vii) IF_7. 4.4 Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_5, PCl_6^-, SF_6, SO_4^{2-}, ClF_3, Cl_2O, BrF_5, I_3^-, BrF_2^+, $TeCl_4$, XeO_3.	**12 Lectures**

Learning Resources

1. Principles of Physical Chemistry by Maron and Prutto, 1992.
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa, 2004.
3. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP, 2000.
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson, 2013.
5. Essentials of physical chemistry Bhal, Tuli and S. Chand, 2010
6. Fundamentals of Analytical Chemistry, Skoog, West and Haller, 1963.
7. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2008.
8. Bodie Douglas and DarlMcdaniel Concepts and Models of Inorganic Chemistry Third Edition, Wiley, 1983.
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 Edition2013.
12. A. Bahl, B. S. Bahl, and G.D. Tuli, Essentials of Physical Chemistry, S. Chand and Co Pvt Ltd 2014. (pages 172-207 for Chemical Bonding).

Course code: CHE1202
Title: Stereochemistry, Hydrocarbons & Mole Concept

Course Learning Outcome	**Suggested Pedagogical Processes**
1. Understand the 3D structure of organic molecules, chirality,optical isomerism,R/S and E/Z configuration. 2. Understand the mechanism of aromatic electrophilic substitution reactions. 3. Understand the concept of mole, molarity, normality, equivalent weight, standard solutions including standardization and its applications in quantitative analysis. 4. Learn the balancing of redox reaction by ion electron method.	1. Lecture method and 3D models. 2. Use of ICT tools. 3. Quiz and seminar. 4. Mind mapping techniques and concept chart 5. Problem solving sessions

UNIT I	**Stereochemistry** 1.1 Introduction to isomerism and its classification. Fischer Projection, Newmann and Sawhorse Projection formulae and their inter conversions. 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. 1.2 Optical isomerism**:** Optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, distereoisomers, meso structures, racemic mixture and resolution, relative and absolute configuration, D/L, R/S and E/Z designations.	**12 Lectures**
UNIT II	**Aromatic Hydrocarbons (10 L)** 2.1 Aromaticity: Hückel's rule, aromatic character of arenes, homocyclic and polycyclic aromatic hydrocarbons (benzene, naphthalene, anthracene), cyclic carbocations/carbanions and heterocyclic compounds with suitable examples (Pyrrole, furan, thiophene, pyridine and its basicity) with their relevance to industry. 2.2 Electrophilic aromatic substitution: Reactions of benzene, naphthalene and anthracene sulphonation, nitration, halogenation, Friedle Craft alkylation/acylation reactions, with their mechanis. 2.3 Directing effects of the groups. Industrial application of aromatic hydrocarbons.	**10 Lectures**
UNIT III	**Recent Trends in Chemistry** 3.1 Introduction to research journals in chemistry, search Engine like Sci-Finder, Google Scholar, C on CD, Reaxis, Nobel Prize winners in Chemistry in last five years.	**2 Lectures**

UNIT IV	**Mole Concept (12 L)** 1.1 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. 1.2 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.	**12 Lectures**

Learning Resources

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

Course code: CHE1203
Title: Chemistry Practical - II

Course Learning Outcome	**Suggested Pedagogical Processes**
1. Understand the concepts andcalculations of heat of solution of KNO_3, universal gas constant 'R' by Eudiometric method, 2. Learn to calculate the dissociation constant of weak acid by *p*H metry and apply the data to study the least square fitting method. 3. Understand the relative viscosity of given organic liquids by Ostwald viscometer. 4. Able to visualize the shapes of s and p orbitals, using polar plots. 5. Understand the quantitative estimations by volumetric and gravimetric methods.	1. Demonstration of experiments. 2. Use of ICT tools. 3. Quiz and seminar. 4. Practice sessions.

UNIT I	**Physical Chemistry Practicals (Any FIVE):** 1.1 Polar plots of *s*, $p_z$orbitals 1.2 Relative viscosity of given organic liquids by viscometer 1.3 Molar gas constants (R)in different units by eudiometric method. 1.4 Interpretation of powder diffraction pattern of 1:1 salts. 1.5 Dissociation constant of a weak acid by *p*H metry. 1.6 To determine molecular weight of solute by depression in freezing point method. Naphthalene – Sulphur. 1.7 To determine molecular weight of given electrolyte (KCl) and on-electrolyte (Urea) by Landberger's method and to study abnormal molecular weight of electrolyte. 1.8 Scientific graphing of following functions using MS-Excel 1.8.1 exponential 1.8.2 logarithmic 1.8.3 linear 1.9 Determination of rate constant of acid catalyzed ester hydrolysis. 1.10 Heat of solution of potassium nitrate in water.	**5 Practicals**
UNIT II	**Analytical Chemistry Practicals (Any FIVE)** 2.1 Cleaning and Maintenance of apparatus and instruments. Calibration of apparatus: 1.1.1 Burette 1.1.2 Pipette 1.1.3 Volumetric flask 1.1.4 Thermometers ($1/10^{th}$, 110^0C and 360^0C) 2.2 Preparation standard solution of 0.05N oxalic acid(exact) and standardization and determination of strength of given 0.05N (approx) $KMnO_4$ solution using two burette method. 2.3 Determination of acetic acid in vinegar by titrimetric method.	**5 Practicals**

	2.4 Determination of percentage composition of ZnO and $ZnCO_3$ in the given mixture gravimetrically. 2.5 Estimation of hydroxide/sulphate and carbonate present together in mixture. 2.6 Estimation of Fe(II) by using standardized 0.05N (approx) $KMnO_4$ solution. Estimation of the amount of Mg (II) present in the given solution complexometrically.	

Learning Resources

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.