SOPHIA COLLEGE (AUTONOMOUS)

Affiliated To
University Of Mumbai

Programme:

Programme Code:

CHEMISTRY

Choice based credit system with effect from the academic year 2019-20

Programme Outline: SYB Sc Chemistry (SEMESTER III)

Course Code	Title of the paper	Unit	Topic	Credits	L/Week
SBSCHE301	Physical and Analytical Chemistry	I	1.1 Chemical Thermodynamics – II 1.2 Electrochemistry – I	2	3
		II	2.1 Chemical Kinetics-II 2.2 Solutions		
		III	3.1Basics in Analytical Chemistry		
SBSCHE302	Inorganic Chemistry	I	1.1 Non directional bonding 1.2 Directional bonding 1.3 Molecular Orbital Theory	2	3
		II	2.1Chemistry of boron compounds 2.2 Chemistry of Silicon and Germanium 2.3 Chemistry of nitrogen family		
		III	3.1Concept and scope of environmental chemistry 3.2 Toxicology 3.3 Environmental restoration		
SBSCHE303	Organic Chemistry	I	1.1 Investigation of reaction mechanism 1.2 Alkyl halides 1.3 Alcohols 1.4 Ethers 1.5 Epoxides	2	3
		II	2.1 Aliphatic Carbonyl Compounds 2.2 Aliphatic Carboxylic Acid & their Derivatives 2.3 Aliphatic Amines		
		III	3.1 Green Chemistry		
Practicals Semester III					
SBSCHEP3	Chemistry	-	-	3	9

	Practical				

Programme Outline: SYB Sc Chemistry (SEMESTER IV)

Course Code	Title of the paper	Unit	Topic	Credits	L/Week
SBSCHE401	Physical and Analytical Chemistry	I	1.1 Phase Equilibria 1.2 Electrochemistry – II	2	3
		II	2.1 Catalysis 2.2 Solid state		
		III	3.1 Titrimetric methods 3.2 Instrumental methods of analysis 3.3 Spectroscopy		
SBSCHE402	Inorganic Chemistry	I	1.1 Chemistry of transition elements 1.2 Co-ordination chemistry	2	3
		II	2.1 Bio inorganic chemistry 2.2 Organometallic Chemistry		
		III	3.1 Physiochemical parameters of water 3.2 Water treatment and purification 3.3 Metallurgy 3.4 Corrosion and protection of metals		
SBSCHE403	Organic Chemistry	I	1.1Nomenclature of polysubstituted Aromatic compounds 1.2 Haloarenes 1.3 Phenols 1.4 Aromatic Carboxylic acids 1.5 Aromatic Sulfonic acids	2	3
		II	2.1 Aromatic nitro compounds 2.2 Aromatic amino compounds 2.3Aromatic aldehydes and ketones		
		III	3.1Industrial Organic Chemistry		

Practicals Semester IV					
SBSCHEP4	Chemistry Practical	-	-	3	9

Preamble

Programme: BSc Chemistry

Chemistry - a vibrant and ever growing science that encompasses every aspect of our lives. The fascinating study of matter and its applications is vital in areas like drug designing, material science, nanotechnology and most importantly, 'green chemistry', areas that are beneficial to both humanity and the environment. Bachelor's degree in Chemistry is the culmination of in-depth knowledge of Inorganic, Organic and Physical chemistry, Analytical chemistry and specialized courses such as Pharmaceutical Chemistry, spectroscopy, Nanoscience, Forensic Science, Cosmeticology, Food chemistry, Dairy Chemistry, Environmental chemistry and so on.

The learning objectives are designed to provide a focused outcome based syllabus with an agenda to structure the teaching learning experiences in a more student centric manner. This programme helps learners in building a solid foundation for higher studies in Chemistry. The hands-on experience the students gain in Practical enable them to apply theoretical knowledge acquired to solve problems in everyday life, think critically and innovatively. The syllabus is designed so that the student starts from the basic concepts of chemistry and will gradually move towards the advanced level. They are given opportunities to improve their creativity, scientific writing and communication skills through assignments and other co-curricular activities in all the semesters. The credit courses on "Positive Health in Women" and "Innovation in Natural dyeing and Entrepreneurship Skills" offered by the department further enhances their life skills and helps them evolve as entrepreneurs.

Students completing this programme will be equipped with knowledge of the concepts of Chemistry, interpret data and present their findings to both the scientific community and laymen. Completion of this programme will also enable the learners to join teaching professions, conducting research in Industry and Government run research labs.

PROGRAMME OBJECTIVES	
PO1	The students are expected to understand the basic concepts in chemistry and be aware of the recent development in the subject area.
PO2	To inculcate critical thinking and scientific attitude in the students.
PO3	The students should be able to apply the theoretical knowledge and practical skills acquired to solve the real world problems and environmental issues.

PROGRAMME SPECIFIC OBJECTIVES	
PSO1	**Core competency:** The chemistry graduates are expected to gain the theoretical and practical knowledge of the basic concepts in chemistry.
PSO2	**Skill development:** They would acquire necessary skills and training to pursue higher studies in the field of chemistry and to be an entrepreneur.
PSO3	**Responsible citizens:** The students will get trained to adopt and practice sustainable techniques for their personal growth and to address societal and environmental problems.

Syllabus for Approval

Serial No.	Heading	Particulars
1	Title of course	SYBSc Chemistry
2	Passing marks	40%
3	Ordinance/Regulation (if any)	
4	No. of Semesters	Two
5	Level	UG
6	Pattern	Semester
7	To be implemented from Academic year	2019-20

Date:

BOS Chairperson
Dr. I. A. Mendes

Convener
Dr. Santosh Haram

SEMESTER 3

NAME OF THE COURSE	**Physical and Analytical Chemistry**	
CLASS	SY BSc	
COURSE CODE	**SBSCHE301**	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

COURSE OBJECTIVES:

CO 1.	To understand and enumerate the concept of entropy, free energy functions, its variation with temperature and pressure, partial molal properties,
CO 2.	To emanate the significance of Van't Hoff Reaction Isotherm & Isochore.
CO 3.	To identify and classify chemical reactions with respect to kinetics identify techniques for fast reactions, the effect of temperature on rate and theories of reaction rate
CO 4.	To introduce the relevance and importance of analytical chemistry

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	understand the different thermodynamic parameters such as entropy, helmholtz free energy, gibbs free energy changes and its significance

CLO 2.	Solve numericals on Gibbs Helmholtz equation, Gibbs-Duhem equation, Van't Hoff Reaction isotherm and isochore.
CLO 3.	understand and extrapolate Raoult's law, deviation of Raoult's law, composition curves, Azeotropes and methods of separating them
CLO 4.	identify and classify the sources of error, calculate accuracy and precision of a method from the given data, and apply significant figures rules accurately.

SEMESTER III
PAPER I - Physical and Analytical Chemistry
Course Code: SBSCHE301

Unit I		
1.1	**Chemical Thermodynamics – II (8L)**	
	1.1.1	Second law of thermodynamics: Statement and concept of entropy.
	1.1.2	Free Energy Functions: Helmholtz Free Energy, Gibbs Free Energy, Variation of Gibbs Free Energy with pressure and temperature, Gibbs Helmholtz Equation. (Numericals expected)
	1.1.3	Thermodynamics of open systems: Partial molal properties, Chemical potential and its variation with pressure and temperature, Gibbs Duhem Equation.
	1.1.4	Vant Hoff Reaction Isotherm and Vant Hoff Reaction Isochore. (Numericals expected)
1.2	**Electrochemistry – I (7L)**	
	1.2.1	Conductivity, Equivalent and Molar Conductivity (Numericals expected) and their variation with dilution of weak and strong electrolytes, Debye Huckel Onsager Equation (no derivation) and its verification.
	1.2.2	Kohlrausch Law of Independent Migration of ions and its application: Determination of Ionization constant of a weak electrolyte, Solubility of a sparingly soluble salt and ionic product of water (Numericals expected)
	1.2.3	Transference Number and Its Experimental Determination using Moving Boundary Method (Numericals expected), Factors affecting Transference number.

Unit II		
2.1	**Chemical Kinetics-II (7L)**	
	2.1.1	Classification of chemical reactions, Techniques for fast reactions: Stopped - flow method and Flash Photolysis.
	2.1.2	Effect of temperature on the rate reaction: Arrhenius Equation (Numericals expected), Concept of energy of activation.
	2.1.3	Theories of Reaction rates: Collision and Activated Complex Theory of Bimolecular Reactions. Comparison between the two theories. (Qualitative treatment only).
2.2	**Solutions (8L)**	
	2.2.1	Thermodynamics of Ideal and Non-Ideal Solutions: Ideal Solutions and Raoult's Law (Numericals expected), Deviations fromRaoult's Law, Non-ideal solutions, Vapour pressure: Composition and Temperature – Composition Curves of Ideal and Non-Ideal Solutions. Distillation of Solutions, Azeotropes and methods of separating them.
	2.2.2	Partial Miscibility of Liquids: Critical Solution Temperature, Effect of impurity on partial miscibility of liquids with respect to Phenol-Water, Triethanolamine-Water and Nicotine-Water systems.
	2.2.3	Immiscibility of Liquids: Principle and method of Steam Distillation. (Numericals expected)
		Unit III
3.1		**Basics in Analytical Chemistry(15 L)**
	3.1.1	Language of Analytical Chemistry: (Important terms and their significance in Analytical Chemistry): Analysis, determination, measurement, techniques, methods, procedures, protocols, sensitivity, selectivity, robustness, ruggedness and scale of operation.
	3.1.2	Classical and non-classical methods of analysis: Their types and importance. Errors: Errors in analysis and its classification, Minimization of errors. Normal
	3.1.3	distribution curve. Precision and accuracy: Methods for their expression:- Absolute error, relative error, mean, mode, median, range, deviation, relative average deviation, standard deviation, relative standard deviation, variance and coefficient of variance (Numericals expected)
	3.1.4	Significant figures and computation: Significant figures, Significance of zero in the computation of analytical data, Rules of computation.
	3.1.5	Calibration of glasswares: Calibration of burette, pipette and standard flask.

PRACTICALS

SEMESTER III
PHYSICAL AND ANALYTICAL CHEMISTRY

COURSE OBJECTIVES:

CO 1.	To learn applications of different concepts, methods and techniques learnt in theory to various chemical reactions/systems.
CO 2.	To prove various laws and equations using different instrumental methods.

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	analyze various compounds by using classical and instrumental methods of analysis
CLO 2.	able to prove or verify laws/equations through simple experiments and calculate rate and order of the reaction for known chemical systems

1. To interpret the order of the reaction graphically for the given experimental data and calculate the specific reaction rate.
2. To investigate the reaction between K_2S_2O8 and KI with equal initial concentration of reactants.
3. To determine the energy of activation of acid catalyzed hydrolysis of methyl acetate.
4. To determine the rate constant for the alkaline hydrolysis of ethyl acetate conductometrically.
5. To determine the dissociation constant of a weak acid conductometrically.
6. To verify the Onsager equation of electrolytic conductance and to determine the equivalent conductance of a strong electrolyte at infinite dilution.
7. To titrate a strong acid against a strong base conductometrically.
8. To estimate copper in the given solution iodometrically.

SEMESTER 4

NAME OF THE COURSE	**Physical and Analytical Chemistry**
CLASS	SY BSc
COURSE CODE	**SBSCHE301**

NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

COURSE OBJECTIVES:

CO 1.	To understand and extrapolate phase rule, phase diagrams and its application
CO 2.	To solve numericals based on cell emf using Nernst equation
CO 3.	To understand and restate the laws of crystallography, symmetry elements, bravais lattice types and use of x-rays in crystal structure determination.
CO 4.	To understand the theory behind major categories of instrumental methods of analysis

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	understand phase rule thermodynamically
CLO 2.	identify different types of electrodes, write the electrode reactions, explain the principle,construction and working of calomel, glass electrodes.
CLO 3.	discuss and emanate catalysis, properties and types of catalyst, reactions with nanoparticles as catalyst and to derive the Michaelis-Menten equation.
CLO 4.	compare and contrast different instrumental methods of analysis

SEMESTER IV
Paper I- Physical and Analytical Chemistry
Course Code: SBSCHE401

Unit I	
1.1	**Phase Equilibria (7L)**

	1.1.1	Phases, Components and Degrees of Freedom of a System, Criteria of Phase Equilibrium, Gibbs Phase Rule: Thermodynamic derivation and its application.
	1.1.2	Phase diagram of one component system: Water and Sulphur.
	1.1.3	Phase diagram of two component system involving Eutectics: Lead- Silver system, Congruent melting point: Zinc-Magnesium System., Incongruent Melting point – Sodium-Potassium system.
	1.1.4	Clapeyrons Equation and Clausius-Clapeyron Equation: Derivation and its importance in phase equilibrium. (Numericals expected)
1.2	**Electrochemistry – II (8L)**	
	1.2.1	Electrochemical Cells: Galvanic cells, Electrochemical conventions, Reversible and Irreversible cells.
	1.2.2	Types of electrodes, Standard electrode potential, Electrochemical series, Nernst Equations: Derivation and its applications. (Numericals expected).
	1.2.3	Calomel electrode, Glass electrode and Salt bridge – Principle, construction and working.
	1.2.4	pH determination using Glass electrode and Quinhydrone electrode. (Numericals expected)
	1.2.5	Equilibrium Constant and Thermodynamic Properties: ΔG, ΔH and ΔS from EMF data. (Numericals expected).
	Unit II	
2.1	**Catalysis (7L)**	
	2.1.1	Types of Catalysis, Catalytic activity, specificity and selectivity. Promoters, Inhibitors and Poisons in Catalysis.
	2.1.2	Mechanism and Kinetics of Acid and Base catalyzed reactions, Effect of pH on the rate of reaction.
	2.1.3	Mechanism and Kinetics of Enzyme Catalyzed Reaction. (Michaelis-Menten's Equation).
	2.1.4	Use of nanoparticles as catalysts.
2.2	**Solid State (8L)**	
	2.2.1	Laws of Crystallography.
	2.2.2	Symmetry elements, Unit cells, Bravais Lattice types, Weiss and Miller Indices.
	2.2.3	Characteristics of Simple Cubic, Body and Face Centered Cubic Lattices, Interplanar distances of basic planes in these lattices. (Numericals expected)
	2.2.4	Use of X-rays in crystal structure determination, X-ray Diffraction method, Bragg's equation (Numericals expected), Structure of NaCland KCl, Determination of Avogadro's Number (Numericals expected).

	Unit III	
3.1	**Titrimetric methods (3L) S, E**	
	3.1.1	Terms involved in titrimetric methods of analysis, conditions suitable for titrimetry

	3.1.2	Types of titrimetry: Neutralization, Redox (iodometry, iodimetry), Precipitation, and Complexometric titrations
3.2	**Instrumental methods of analysis (4L) S E**	
	3.2.1	Basic concepts in Instrumental methods : Relation between the analyte, stimulus and measurement of change in the observable property.
	3.2.2	Types of Analytical Instrumental methods (only principle) based on: (i) Optical Interaction: UV- Visible Spectroscopy, Polarimetry (ii) Electrochemical interactions: Potentiometry, pH metry and Conductometry (iii) Thermal interactions: Thermogravimetry
3.3	**Spectroscopy (8L) S E**	
	3.3.1	Instrumentation for absorption spectroscopy: Colorimeters and spectrophotometers, Block diagram of single and double beam colorimeter and spectrophotometer, Principle, construction and working.
	3.3.2	Applications of UV-Vis spectroscopy: (i) Qualitative analysis (ii) Quantitative analysis by calibration curve method.
	3.3.3	Photometric titrations: Principle, working, types of curves and applications.

PRACTICALS

SEMESTER IV
PHYSICAL AND ANALYTICAL CHEMISTRY SE

COURSE OBJECTIVES:

CO 1.	To understand applications of various instrumental methods to various systems
CO 2.	To evaluate simulated data
CO 3.	To understand and perform experiments based on optical methods

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	Generate data to find out rate and order of reaction
CLO 2.	use potentiometry for analysis of various compounds and to construct an electrochemical cell
CLO 3.	analyze commercial samples by optical methods at very low concentration

1. To statistically evaluate the given analytical data for its accuracy and precision.
2. To determine the standard EMF and the standard free energy of the Daniel cell potentiometrically.

3. To determine the amount of HCl in the given sample potentiometrically using Quinhydrone electrode.
4. To determine the amount of Fe (III) in the given solution by titrating against $K_2Cr_2O_7$potentiometrically.
5. To conduct a pH titration of a weak acid against a strong base and to find out its dissociation constant.
6. To determine the amount of aspirin in a commercial sample by colorimetry.
7. To determine the concentration of Cu (II) in the given solution by colorimetry.
8. To determine the percentage of optically active substance in a given solution (glucose/sucrose) polarimetrically.

REFERENCE-Theory

1. Physical Chemistry by G.M. Barrow. Tata McGraw-Hill (2007)
2. Physical Chemistry by G.W. Castellan. Narosa 4th Edition (2004)
3. General Chemistry by Kotz J.C., Treichel P.M. & Townsend. Cengage Learning India Pvt. Ltd., New Delhi (2009)
4. University Chemistry by B.H. Mahan. Narosa 3rd Edition (1998)
5. General Chemistry by R.H. Petrucci. Macmillan Publishing Co., New York 5th Edition (1985)
6. A textbook of Physical Chemistry by K.L. Kapoor. Macmillan Publishing Co., New Delhi 3rd Edition (2001)
7. Analytical Chemistry by G. L. David Krupadanam, D.Vijaya Prasad and others. University Press.
8. Modern Analytical Chemistry by David Harvey. Mc Graw-Hill International Edition.
9. Fundamental of Analytical Chemistry by Skoog, West, Holler and Crouch. Indian Edition
10. Analytical Chemistry by D. Kealey and P.J. Haines.
11. Quality Assurance in Analytical Chemistry by Elizabeth Prichard and Vicki Barwick. John Wiley and Sons, Ltd.
12. Analytical Chemistry by Open Learning series (ACOL)-Wiley India Edition.

REFERENCE-Practicals

1. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg & A. Gulati. R. Chanda and Co., New Delhi (2011)
2. Experiments in Physical Chemistry by C.W. Garland, J.W. Nibler& D.P. Shoemaker. McGraw-Hill New York 8th Edition (2003)
3. Experimental Physical Chemistry by Halpern A.M. & G.C. McBane. W.H. Freeman and Co., New York (2003)
4. Experimental Physical Chemistry by V.D. Athawale and P. Mathur. New Age International, New Delhi (2001)
5. Practical Physical Chemistry by Vishwanathan B. and RaghavanP.S.. Viva Books (2017)

6. Systematic experimental physical chemistry by Rajbhoj S.W. and Chondhekar T.K. Anjali Publication (2013)
7. Physical Chemistry – A Lab Manual by Sinha S.K. Narosa Publication (2014)
8. Vogel's Textbook of Quantitative Chemical Analysis. Pearson Publication

SEMESTER 3

NAME OF THE COURSE	**Inorganic Chemistry**	
CLASS	SY BSc	
COURSE CODE	**SBSCH 302**	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1.	To understand the bonding fundamentals for both ionic and covalent compounds, including electronegativities, bond distances and bond energies using MO diagrams and thermodynamic data. To predict geometries of simple molecules
CO 2.	To understand the fundamentals of the chemistry of the main group elements, and important real world applications of many of these species
CO 3.	To introduce the importance of environmental chemistry, components of atmosphere and biogeochemical cycles
CO 4.	To get a knowledge of different types of pollution with reference to source and control measures

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	differentiate between ionic and covalent compounds, and explain their properties using different theories, predict and understand geometries of different covalent compounds
CLO 2.	identify and analyze different properties of main group elements
CLO 3.	understand interdependence of biotic and abiotic components

CLO 4.	identify and classify sources of pollutants and analyze the man made disasters from a chemistry point of view

SEMESTER III
Paper - II Inorganic Chemistry
Course Code: SBSCHE302

UNIT I		
1.1	**Non-Directional Bonding (4L)**	
	1.1.1 1.1.2 1.1.3	Ionic Bond: Introduction, conditions for the formation of an ionic bond. Ionic crystals: definitions-crystal lattice, lattice points, unit cell, lattice parameters, types of ionic crystals Lattice Energy: Borne-Lande equation, Kapustinski equation, Born-Haber Cycle and its application (Numericals expected)
1.2	**Directional bonding (6L)**	
	1.2.1 1.2.2 1.2.3 1.2.4 1.2.5	Covalent Bonding: Valence Bond Theory- introduction and basic tenets Formation of H_2 :Interaction between two hydrogen atoms and the potential energydiagram of the resultant system, corrections applied to the system of two hydrogen atoms Hybridization and types of hybrid orbitals- *sp, sp^2,sp^3,sp^3d, sp^3d^2* Equivalent and Non-Equivalent hybrid orbital Limitations of VBT
1.3	**Molecular Orbital Theory(5L)**	
	1.3.1. 1.3.2. 1.3.3 1.3.4	Introduction to MOT, definitions- bonding, anti-bonding and non-bonding molecular orbitals LCAO- MO approach to homonuclear diatomic molecules H_2 to Ne_2 (calculation of bond order and magnetic property) Bond Order and magnetic property of species of O_2 : $O2^+$O,$O2^{2-}$ LCAO- MO approach to heteronuclear diatomic molecules- HCl, NO, CO(calculation of bond order and magnetic property)
UNIT II		
2.1	**Chemistry of Boron compounds (4L)**	
	2.1.1 2.1.2	Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. Preparation of simple boranes like diborane and tetraborane, Structure and bonding in diborane and tetraborane (2e-3c bonds)

	2.1.3	Preparation and applications of borax
2.2	**Chemistry of Silicon and Germanium (5L)**	
	2.2.1 2.2.2 2.2.3 2.2.4 2.2.5	Silicon compounds: Occurrence, structure and inertness of SiO_2 Preparation and structure of $SiCl_4$ Germanium:Occurrence and extraction Preparation of pure Silicon and Germanium Uses of Silicon and germanium
2.3	**Chemistry of Nitrogen family (6L)**	
	2.3.1 2.3.2 2.3.3	Trends in chemical reactivity of compounds of elements of group 15- hydrides, halides and oxides Oxides of nitrogen with respect to preparation and structure of NO, NO_2, N_2O and N_2O_4. Synthesis of ammonia by Bosch – Haber process- physicochemical principles
	UNIT III	
3.1	**Concept and scope of environmental Chemistry (5L)**	
	3.1.1 3.1.2 3.1.3 3.1.4	Components of the environment-biotic and abiotic. Composition of various segments of the environment: atmosphere, hydrosphere, lithosphere, biosphere. Natural Chemical processes - Carbon, nitrogen and oxygen cycles Environmental pollution: air pollution, soil pollution and water pollution – effects and control measures
3.2	**Toxicology (8L)**	
	3.2.1 3.2.2 3.2.3	Concept, effects - biochemical and physiological Toxicity of chemicals i) Metals: As, Hg, Pb, Cd, Cr w.r.t origin in the environment, ill effects, control measures ii)Non-metals: oxides of carbon, nitrogen and sulphur (photochemical smog and greenhouse gases) Case studies: London smog, Bhopal gas tragedy, Minamata disease, Chernobyl disaster
3.3	**Environmental restoration (2L)**	
	3.3.1	Concept of 4 R's: Reduce, Reuse, Recycle and Recover

PRACTICALS
SEMESTER III
INORGANIC CHEMISTRY

COURSE OBJECTIVES:

CO 1.	to identify different anions and cations present in a mixture
CO 2.	to determine the amount of elements present in a given solution gravimetrically
CO 3.	to determine the amount of elements present in a given solution complexometrically

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	identify and analyze ions present in a given mixture by semi-micro inorganic qualitative analysis.
CLO 2.	analyze and report the amount of elements present by doing gravimetric analysis.
CLO 3.	analyze and report the amount of elements present in a given solution by using complexometric reactions.

1. Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions using the H_2S scheme for precipitation of cations (minimum 6 mixtures)
   Cations (from amongst):Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+} ,Mg^{2+}, Al^{3+} ,Cr^{3+},Cd^{2+}, Fe^{3+},Zn^{2+}, Co^{2+}, Sb^{3+},K^{+}, NH_4^{+}
   Anions(from amongst):CO_3^{2-}, S^{2-} ,SO_3^{2-},NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4^{3-}, CrO_4^{2-}, $Cr_2O_7^{2-}$
2. To determine the amount of magnesium ions in the given solution gravimetrically
3. To determine the amount of magnesium ions in the given solution complexometrically.

SEMESTER 4

NAME OF THE COURSE	**Inorganic Chemistry**	
CLASS	SY BSc	
COURSE CODE	**SBSCHE302**	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1.	To gain understanding of transition metal ions and their properties and build knowledge on coordination complexes and their application in bioinorganic chemistry
CO 2.	To introduce the quality parameters of water
CO 3.	To learn various metallurgical operations
CO 4.	To learn about the importance and steps in the treatment of effluent and to learn about corrosion and its control measure

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	identify and list different transition metal ions and their properties and understand bonding in coordination complexes, naming of coordination compounds and explain their magnetic properties
CLO 2.	write and perform analysis of water to assess its quality
CLO 3.	understand different stages in the process of metallurgy and the chemical reactions involved .
CLO 4.	to understand and explain the importance of various steps in the effluent treatment plant and identify the factors responsible for corrosion and to suggest appropriate methods for its prevention

SEMESTER IV
PAPER II - Inorganic Chemistry
Course Code: SBSCHE402

UNIT I		
1.1	**Chemistry of transition metals (8L)**	
	1.1.1	Position in the periodic table, natural occurrence, principal ores and minerals of elements of the first transition series.
	1.1.2	Oxidation states,origin of colour of transition metals and their

		compounds: d-d transitions and charge transfer
	1.1.3	Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons; equation for spin only and spin-orbital magnetism terms of Bohr magnetons (No derivation of relevant equations expected); Reasons for quenching of orbital moment of electrons
	1.1.4	Uses of transition elements
1.2	**Coordination Chemistry (7L)**	
	1.2.1	Introduction: Basic terms, types of ligands, nomenclature of co-ordination compounds, isomerism and its types
	1.2.2	Werner's theory of coordination, effective atomic number rule
	1.2.3	Nature of the Metal-Ligand Bond:Valence Bond Theory: hybridisation -sp^3, dsp^2, sp^3d^2,d^2sp^3 (Inner and outer orbital complexes of Mn(II), Fe(II),Fe(III),Co(II),Co(III),Ni(II), Cu(II), Zn(II) with ligands like aqua, ammonia,cyanide and halides)
	1.2.4	Limitations of V.B.T with respect to co-ordination compounds.
	1.2.5	Uses of coordination compounds: medicinal, biological, industrial and as laboratory reagents
	UNIT II	
2.1	**Bioinorganic chemistry (7L)**	
	2.1.1	Introduction, essential and non-essential elements and their role in biological systems
	2.1.2	Role of metal ions in biological systems: Na(I) and K(I)- ion pumps (mechanism), Fe(II) and Fe(III) [oxygen transport (mechanism), electron transfer and iron storage] and Mg(II) [photosynthesis (mechanism)]
2.2	**Organometallic Chemistry (8L)**	
	2.2.1	Introduction, definition, classification based on heptacity and nature of metal –carbon bond, methods of preparation
	2.2.2	Applications of organometallic compounds in organic synthesis as catalysts : Zeigler Natta and Wilkinson (with mechanism)
	2.2.3	Metal carbonyls: bonding, properties and methods of preparation, eighteen electron rule and its applications and exceptions
	UNIT III	
3.1	**Physicochemical parameters of water (3L)**	
	3.1.1	Dissolved oxygen, chemical oxygen demand and its measurement, biochemical oxygen demand and its measurement, pH, total dissolved salts, total suspended solids, total hardness, effect of these

		parameters on the ecosystem
3.2	**Water treatment and purification (4L)**	
	3.2.1 3.2.2	Effluent treatment plants: primary, secondary, tertiary, sludge disposal Treatment of industrial effluent from electroplating and tannery industry
3.3	**Metallurgy (4L)**	
	3.3.1 3.3.2	Basic steps involved in metallurgy Extraction of metals i. Cu by pyrometallurgy and electrolysis ii Ag by hydrometallurgy iii Al by electrometallurgy
3.4	**Corrosion and Protection of metals (4L)**	
	3.4.1 3.4.2.	Introduction, types of corrosion, Electrochemical theory of corrosion (no derivation) Importance of protection of metals from corrosion, methods of protection viz. coating, electroplating, cathodic protection, anodizing, sacrificial coating

PRACTICALS
SEMESTER IV
INORGANIC CHEMISTRY

COURSE OBJECTIVES:

CO 1.	to determine the amount of analyte present in a given solution gravimetrically
CO 2.	to determine the amount of analyte present in a given solution complexometrically

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	report the amount of ions present by doing gravimetric analysis
CLO 2.	report the amount of ions present in given solution by using complexation reaction

1. To determine the amount of nickel ions in the given solution gravimetrically.

2. To determine the amount of barium ions in the given solution gravimetrically.
3. To estimate the amount of zinc ions in solution complexometrically.
4. To determine the total hardness of water.
5. To determine the dissolved oxygen in the given water sample.
6. To determine the chemical oxygen demand of the given water sample.
7. To determine the percentage composition of calcium oxide / magnesium oxide in the given dolomite sample complexometrically.
8. To determine the percentage of nickel in the given sample of cupronickel alloy/synthetic sample complexometrically.

REFERENCE–Theory

1. Concise inorganic chemistry, J D Lee, Blackwell Science Ltd, fifth edition.
2. Principles of structure and reactivity, James Huheey, Addison Wesley publishing company, fourth edition
3. Environmental Chemistry, A K De,New Age publication, sixth edition
4. Fundamental concepts of environmental chemistry, G.S. Sodhi, Narosa, second edition

REFERENCE –Practical

1. Vogel's qualitative inorganic analysis, G. Svehla, Orient Longman, sixth edition
2. Semi-micro qualitative analysis, Velcher and Hahn, East West Press
3. A textbook of quantitative inorganic analysis, Athur I. Vogel, Longman, 3rd edition
4. A. I. Vogel's *Quantitative Chemical Analysis,* Mendham,Pearson ,*6th Edition*

SEMESTER 3

NAME OF THE COURSE	**Organic Chemistry**	
CLASS	SY BSc	
COURSE CODE	**SBSCH 303**	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

COURSE OBJECTIVES:

CO 1.	To understand various ways of determining the reaction mechanism
CO 2.	Learn aliphatic compounds with respect to physical properties, preparations, reactions
CO 3.	To learn and apply mechanism of selected reactions
CO 4.	To understand and gain knowledge about the importance and need of green chemistry

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	predict and write the mechanism of a reaction under given conditions
CLO 2.	Predict the product for given reactions and identify and arrange the given compounds as per acidity and basicity.
CLO 3.	interconvert functional groups
CLO 4.	elaborate the applications of Green Chemistry in current industrial scenario

Semester III
Paper III- Organic Chemistry
Course Code: SBSCHE303

	Unit I	
1.1	**Investigation of reaction mechanisms: (4L)**	
		Product analysis including cross-over products, trapping of intermediates, isotopic labeling, kinetic and stereochemical evidence.
1.2	**Alkyl halides (3L)**	
		Nucleophilic substitution reactions: S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and factors affecting the rates of nucleophilic substitution reactions-nature of substrate, solvent, nucleophilic reagent and leaving group.
1.3	**Alcohols:** (3L)	
	1.3.1 1.3.2 1.3.3	Preparation: hydration, Oxymercuration-Demercurationand hydroboration of alkenes, reduction of aldehydes and ketones and using Grignard reagent. Properties: Hydrogen bonding- types and effect on different properties. Reactions of alcohols: Alcohols as acids, conversion of alcohols into mesylates

		and tosylates and alkyl halides.
1.4	**Ethers : (2L)**	
	1.4.1 1.4.2 1.4.3	Preparation : Dehydration of alcohols (mechanism), Willamson synthesis (mechanism). Reactions : Acid catalyzed cleavage reaction with HX (mechanism). Applications : Ethers, and crown ethers (12-crown-4 and 18-crown-6).
1.5	**Epoxides : (3L)**	
	1.5.1 1.5.2 1.5.3	Preparation: Oxidation of olefins, Reaction of per acids with olefins, from vicinal halohydrins. Reactions: Reactivity, Ring opening reactions by nucleophiles (i) In acid conditions: hydrolysis, reaction with – HX, alcohol, HCN (ii) In neutral or basic conditions:Reaction with ammonia, amines, metal cyanides, and alkoxides. Applications of epoxides.
	Unit II	
2.1	**Aliphatic Carbonyl Compounds: (4L)**	
	2.1.1 2.1.2 2.1.3 2.1.4	Structure and reactivity of aldehydes and ketones Preparation: Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, from esters using Grignard reagent. Reactions of aldehydes and ketones: General mechanism of nucleophilic addition and acid catalyzed nucleophilic addition. Reactions with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$. Keto-enol tautomerism, Mechanism of acid and base catalyzed enolization.
2.2	**Aliphatic Carboxylic Acids and their Derivatives: (8L)**	
	2.2.1 2.2.2 2.2.3	Structure and physical properties: acidity of carboxylic acids, effects of substituents on acid strength of aliphatic carboxylic acids. Preparation of carboxylic acids: oxidation of alcohols, carbonation of Grignard reagent and hydrolysis of nitriles. Reactions: Mechanism of nucleophilic acyl substitution and acid-catalyzed nucleophilic acyl substitution. Relative reactivity of Acyl compounds. Interconversion of acid derivatives by nucleophilic acyl substitution. Salt formation, decarboxylation, Reduction of carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinskyreaction, conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides. Mechanism of Claisen condensation and Dieckmann condensation
2.3	**Aliphatic Amines : (3L)**	
	2.3.1 2.3.2 2.3.3	Basicity and effect of substituents on basicity of aliphatic amines. Preparation: Chemical reduction using Fe-HCl, Sn-HCl, Zn-acetic acid, reduction of nitriles, alkylation of ammonia, reductive amination, Hofmann degradation reaction. Reactions: Salt formation, N-alkylation, Hofmann elimination reaction, reaction

		with nitrous acid, carbylamine reaction.
Unit III		
3.1	**Green Chemistry: (15L)**	
	3.1.1	Green chemistry: Definition, need, importance. 12 principles of green chemistry with relevant examples. Concepts and simple calculations based on – Yield and Selectivity, E-factor, Atom economy. Examples of green chemistry in industry. i) Green starting materials-commodity chemicals from glucose. ii) Green reactions-halide free synthesis of aromatic amines. iii) Green reagents-selective methylation using dimethyl carbonate. iv) Green chemical solvents-use of supercritical carbon dioxide. v) Green chemical products-synthesis of thermal polyaspartates. vi) Green chemistry and catalysis-novel homogenous, heterogenous and enzymatic catalysts in industry. vii) catalytic liquid phase selective hydrogenation of nitrobenzene to p-aminophenol. viii) liquid phase air oxidation of p-cresol to p-hydroxybenzaldehyde.
	3.1.2	Examples of Green synthesis/ reactions and some real world cases i) Green synthesis of Adipic acid , catechol, disodium iminodiacetate (alternate to Strecker Synthesis) ii) Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid; microwave assisted reactions in organic solvents Diels-Alder reaction. iii) Ultrasound assisted reactions: sonochemicalSimmon- Smith reaction (Ultrasonic alternative to Iodine) iv)An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Practical
Semester III
ORGANIC CHEMISTRY

COURSE OBJECTIVES:

CO 1.	learn to prepare derivatives of a given functional group
CO 2.	understand and restate the Green Chemistry principles involved in green reactions

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	identify the compound based on their functional group derivatives
CLO 2.	prepare organic compounds based on green chemistry principles.

Preparation of derivatives:

1. Acetyl derivative-phenols/amine
2. Bromination of phenols/ amines
3. 2,4-DNPH derivative of aldehydes and ketones
4. Oxidation of aldehydes
5. Nitro derivatives of aromatic hydrocarbons
6. Hydrolysis of esters

Green Chemistry experiments

- Microwave: Microwave assisted one-pot synthesis of some of the organic derivatives
- Atom economy: Calculation of atom economy of the following reactions
  Preparation of propene by two methods- from tertiary amines and propene
- Use of enzymes as catalysts- Benzoin condensation using Thyamine hydrochloride as a catalyst instead of cyanide.
- Alternative sources of energy- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

SEMESTER 4

NAME OF THE COURSE	**Organic Chemistry**	
CLASS	SY BSc	
COURSE CODE	**SBSCHE303**	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	3	
TOTAL NUMBER OF LECTURES PER SEMESTER	45	
EVALUATION METHOD TOTAL MARKS PASSING MARKS	INTERNAL ASSESSMENT 50 20	SEMESTER END EXAMINATION 50 20

COURSE OBJECTIVES:

CO 1.	Learn the method of naming aromatic compounds
CO 2.	Gain understanding of various ways of determining the reaction mechanism
CO 3.	Learn aromatic compounds with respect to ○ physical properties, preparations, reactions and ○ mechanism of selected reactions
CO 4.	Understand various industrial procedures involved in production of fuel from crude oil

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	predict and write the mechanism of a reaction under given conditions
CLO 2.	predict the product for given reactions and identify and arrange the given compounds as per acidity and basicity.
CLO 3.	interconvert functional groups using sulphonic acid derivatives
CLO 4.	write the name/draw structure of a given aromatic organic compound

Semester IV
Paper III - Organic Chemistry
Course Code: SBSCHE403

	Unit I	
1.1	**Nomenclature of polysubstituted aromatic compounds(2L)**	
		Benzene, Naphthalene and anthracene contain different functional groups.
1.2	**Haloarenes: (4L)**	
	1.2.1	Preparation of Haloarenes:– Halogenation of benzene and substituted benzenes with molecular halogens (mechanism).
	1.2.2	Reactions of haloarenes: Lack of reactivity of aryl halides under S_N1 and S_N2 reactions. General mechanism (addition – elimination) of aromatic nucleophilic substitutions on the reaction – hydrolysis and amination of haloarenes. Benzyne intermediate mechanism (elimination – addition) of aromatic nucleophilic substitution reaction (cine substitution)
	1.2.3	Applications of aromatic halogen compounds. Ullmann reaction.
1.3	**Phenols: (3L)**	
	1.3.1	Preparation of phenols: from (i) halobenzenes, (ii) aromatic sulfonic acids (benzene and naphthalene sulfonic acids) (iii) isopropyl benzene by

	1.3.2 1.3.3	hydroperoxide method. Reaction of phenols: Acidity of phenols – effect of substituents on acidity of phenols. Salt formation, Etherification – direct reaction with alcohol, Williamson Synthesis, O-acylation, Halogenation, Nitration, Fries rearrangement of aryl carboxylates, Claisen rearrangement of allyloxy arenes. Applications of phenols.
1.4.	**Aromatic Carboxylic acids and their derivatives (3L)**	
	1.4.1 1.4.2 1.4.3	Preparation of mono-and-di-carboxylic acids: Preparation by side chain oxidation of alkyl benzenes, reaction of Grignard reagents with solid carbon dioxide, hydrolysis of aryl nitriles, Kolbe-Schmitt reaction (mechanism) Reactions of aromatic carboxylic acids: Acidity, Effect of substituent on the acidity of benzoic acid, Acid catalyzed esterification, Reduction and decarboxylation. Applications of aromatic carboxylic acids.
1.5	**Aromatic sulfonic acids (3L)**	
	1.5.1 1.5.2 1.5.3	Preparation of aromatic sulfonic acids: Commonly used sulfonating agents. Sulfonation of benzene (with mechanism), monosubstituted benzene and naphthalene. Reactions: Acidity of arene sulfonic acids, comparative acidity of carboxylic acids and sulfonic acids, salt formation, desulfonation, IPSO substitution, $-SO_3H$ as solubilizing and blocking group, preparation of sulfonate ester. Uses of p-TSA, sulfonated polystyrene, naphthalene mono sulfinic acids.
	Unit II	
2.1	**Aromatic nitro compounds: (3L)**	
	2.1.1 2.1.2 2.1.3	Preparation:Nitration using mixed acid, Preparation of mononitro and dinitro compounds by nitration of benzene (mechanism), nitrobenzene, toluene, chlorobenzene, naphthalene, anisole. Reactions: Reduction of nitro compounds under different conditions. Applications of nitro compounds : In the preparation of amines and explosives
2.2	**Aromatic amino compounds: (5L)**	
	2.2.1 2.2.2 2.2.3	Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, metal reduction– Fe-HCI, Sn-HCI, Zn-acetic acid, Selective reduction of dinitrobenzene, Hofmann bromamide reaction. Reactions : Basicity of aromatic amines – effect of substituents on basicity of aniline, salt formation, N-alkylation, N-acylation, halogenations, reductive alkylation, diazotization of aromatic primary amines (mechanism) Reactions of aryl diazonium salts-Sandmeyer, Gattermann and Gomberg reactions, Replacement of diazo group by -H, -OH, -CN, -I, -F, reaction. Azo-coupling reaction with phenols/naphthols and aromatic amines. Reduction of diazonium salt to aryl hydrazine. Formation of azo-and hydrazobenzene.
2.3	**Aromatic Aldehydes and Ketones: (7L)**	

	2.3.1	Preparation of aromatic aldehydes : Preparation using CO (Gattermann-Koch reaction) HCN (Gattermann reaction) $DMF/POCl_3$, (Vilsmerier – Haack reaction) Reimer-Tiemann reaction (mechanism) Rosenmund reaction.
	2.3.2	Preparation of aromatic ketones: Friedel-Crafts acylation using acid chloride and acid anhydride (mechanism)
	2.3.3	General reaction: Reactions with -Ammonia and amines, hydroxylamine, phenylhydrazine, hydrogen cyanide, sodium bisulphate.Reactions with mechanism :Knoevengel reaction, Claisen-Schmidt reaction, Benzoin reaction, Cannizzaro reaction
	2.3.4	Application of aromatic aldehydes and ketones.
	Unit III (15L)	
	3.1 Industrial Organic Chemistry	
	3.1.1	Economics of Chemical Processes Capital Costs, Production, Costs, Research and Development Costs. Effect of Scale on Costs.
	3.1.2	Basic Raw Material for Organic Chemicals Coal, Petroleum, Natural Gas
	3.1.3	Chemical Processing Technology Batch and continuous processing, Catalytic Reactors, Yield and Conversion in Chemical Processes
	3.1.4	Reactions of Alkanes and cycloalkanes Petroleum Refining reactions, Catalytic Alkylation, Catalytic Isomerisation, Catalytic reforming, Catalytic Cracking, Hydrocracking
	3.1.5	Petrochemical Processes Thermal cracking of Alkenes, Acetylene Processes, Catalytic Reforming for Aromatics, Steam reforming
	3.1.6	Intermediates Dyes and their application: raw materials for dye industry, Nitration, SulfonationandHalogenation- Unit Process in the manufacture of Intermediates.

Practical
Semester IV
ORGANIC CHEMISTRY

COURSE OBJECTIVES:

CO 1.	Qualitatively analyze the given mono and bifunctional organic compounds using microtechniques.
CO 2.	analysis of given organic compounds based on functional group specific reactions

COURSE LEARNING OUTCOMES:

The learner will be able to

CLO 1.	identify the given mono and bifunctional organic compound
CLO 2.	estimate the amount of organic compound present in the given sample using suitable method

Systematic Qualitative Analysis of organic compounds with mono and bifunctional groups. (acidic, phenolic,alcoholic,aldehydic, ketonic, amide, nitro, amines, esters, hydrocarbons,thioamides etc.). Minimum of 6 compounds

Organic Estimation

Estimation of equivalent weight of acid.
Estimation of acetamide.
Estimation of acetone.
Estimation of aniline.

References-Theory

References:

- Graham Solomons, T.W., FryhleC.b.&Dnyder, S.A *Organic Chemistry* John Wiley & Sons 7th Edition.
- Mc Murry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition 2013.
- Sykes, P. *A Guide to Mechanism in Organic Chemistry*, 6th Ed. Orient Longman, New Delhi (1988)
- Paula Y. B., *Organic Chemistry*, 3rd Ed. Pearson Education, Inc.
- Morrison, R.T. Boyd & R.N. Bhattacharjee, S.K., *Organic Chemistry,* 7th Ed. Pearson Education Inc.
- Wiseman P. *An Introduction to Industrial Organic Chemistry,* Applied Science Publishers Ltd.
- Shreve, D.K., *Chemical Process Industries,* McGraw-Hill Series in Chemical Engineering

References- Practicals

- Vogel, A.I., Tatchell, A.R.,Furnis B.S. Hanaford, A.J..J &Smith P.W.G, *Textbook of Practical Organic Chemisry,* Prentice-Hall, 5th Edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

- Ahluwalia, V.K. &Aggrawal, R. *Comprehensive Practical Organic Chemistry*, University Press

Paper Pattern for Chemistry
Semester End Exam (50 marks)
SYBSc

Q1) Unit I : MCQs [17 marks]
Q2) Unit II : MCQs [17 marks]
Q3) Unit III :MCQs [16 marks]

Internal Assessment (50 Marks)

Best of three assesements
Two test for 25 Marks: MCQ/ Subjective
One assignment for 25 Marks
Best of two marks to be considered

Practicals:
Mark breakup: Each paper
25 Marks - Experiment
15 Marks - MCQs
5 Marks Journal 5 Marks Viva

Internal Assessment (50 Marks)

Best of two of three
25 Marks: Written Test (2)
25 Marks assignment