# DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.

NAAC Re-Accredited **'A'** Grade

# SYLLABUS
# OF
# PG CET FOR ADMISSION
# TO
# M. Sc. (CHEMISTRY) 2018

# CHEMISTRY

## Atomic Structure :

Atomic orbital's, Quantum numbers, Heisenberg uncertainty principle, shapes of s, p, d orbital's. Aufbau and Pauli exclusion principles. Hund's multiplicity rule. Electronic configurations of the elements, Bohr's atomic model (Qualitative aspect only).

## Periodic Properties :

Atomic and Ionic radii, Ionization Energy, Electron affinity and Electro negativity. Trends in periodic table and application in predicting and explaining the chemical behavior.

## S - Block Elements :

Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their functions in biosystems.

## P - Block Elements :

Comparative Study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides oxides of groups 13-16. Interhalogen compounds and its types

## Chemistry of noble gases :

Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

## Chemical Bonding :

Covalent Bond - Valence theory and its limitations, directional characteristic of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, Valence shell electron pair repulsion (VSEPR) theory of NH3, SF4, CIF3, ICI2 and H2O. MO theory, homonuclear (He, N2 and O2) and heteronuclear (CO and NO) diatomic molecules, bond strength and bond energy, percentage ionic character from dipole moment and electro negativity difference.

Ionic Bonds - Definitions, Factors affecting ionic bond formation.

Hydrogen bonding, Van-der-Waals forces, Metallic bond and its free electron concept.

## Nuclear Chemistry :

Definition; Atomic number, mass number, Isotopes, Isobars mass defect and Binding Energy, Packing fraction N/Z ratio, Radio activity, properties of $\alpha$, $\beta$ and $\gamma$, Artificial transmutation. Applications with respect to trans-uranic elements, carbon dating.

## Theory of volumetric Analysis :

Types of titrations, volumetric apparatus, calibration of pipette and burette. Indicators used in pH - titrations, oxidizing agents used in titrations. Theory of Internal, External and self indicators for redox titration.

## Chemistry of Elements of First Transition Series :

General Characteristic features of d-block elements. Properties of the elements of the first transition series: Ionic Size, Atomic Size, Metallic properties, Ionization potential, magnetic properties, Oxidation State.

## Co-ordination Compounds :

Werner's Co-ordination Theory and its experimental verification effective atomic Number concept, chelates, nomenclature of co-ordination compounds, isomerism in co-ordination compounds, valence bond theory of transition metal complexes.

## Chemistry of Lanthanide Elements :

Occurrence and Isolation of Lanthanides,Electronic Configuration Oxidation states, Ionic Radii, Lanthanide Contraction and its Consequences.

## Chemistry of Actinides :

Occurrence, Position in the periodic table, Electronic configuration. Oxidation State, chemistry of separation of Np, Pu and Am from U

## Acids and Bases :

Arrhenius, Bronsted-Lawry, The Lux-Flood, Solvent System and Lewis Concept of Acids and Bases

## Non- Aqueous Solvents :

Physical Properties of a solvent, Types of Solvents and their general Characteristics, Reaction in Non-Aqueous Solkvents with reference to liquid $NH_3$ and liquid $SO_2$.

## Metal-Ligand Bonding in Transition Metal Complexes :

Limitations of Valence Bond Theory An Elementary idea of Crystal Field Theory Crystal Field Splitting in Octahedral, Tetrahedral and Square Planar Complexes Factors affecting Crystal Field Parameters

## Electronic Spectra of Transition Metal Complexes :

Types of Electronic Transitions Selection rules for d -d transitions Spectro -chemical series Orgel Energy level diagram for d1, d5 and d9 Electronic Spectrum of [Ti (H2O)6]3+ complex ion.

## Organometallic Compounds :

Definition, Nomenclature and classification of Organometallic Compounds Preparation, Properties, Bonding and Applications of alkyls and aryls of - Li, Al, Hg, Sn and Ti. A Brief account of metal - ethylenic Complexes Nature of bonding in metal carbonyls.

## Bioinorganic Chemistry :

Essential and trace elements in biological processes Metalloporphyrins with special reference to hemoglobin and myoglobin Biological role of alkali (Na+, K+ ) and alkaline earth metal ions(Mg2+, Ca2+ ). Nitrogen fixation.

## Chromatography :

Definition and classification of chromatography Paper and Thin Layer Chromatography Method of Development (Ascending, Descending Chromatography) Locating Technique (UV-light / Chemicals) R f value Comparison between paper and TLC Applications.

## Structure and Bonding :

Localized and delocalized chemical bond; charge transfer complexes, resonance, hyper conjugation, inductive effect, hydrogen bonding, conjugative effect, steric effect.

## Mechanism of Organic Reactions :

Homolytic and heterolytic bond breaking. Types of reagents eletrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates - carbocations, carbanions, free radicals (with two examples each).

## Stereochemistry of Organic Compounds :

Concept of Isomerism - Types of isomerism

Optical Isomerism - elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, diastereomers, threo and erythro diastereomers, meso compounds.

Relative and absolute configuration, sequence rules, D and L and R and S systems of nomenclature.

Geometric Isomerism - Determination of configuration of geometric isomers. E and Z system of nomenclature, geometric isomerism in oximes and alicylic compounds.

## Alkanes :

Methods of formation (Koble reaction, Corey - House reaction and decarboxylation of carboxylic acids) Physical properties and Chemical reactions of alkanes Chlorination, Nitration, Sulphonation, Catalytic oxidation.

## Alkenes :

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides. The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes - mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration and oxidation with KMnO4. Polymerization of alkenes with one example each.

## Arenes and Aromaticity :

Nomeclature of benzene derivatives. The aryl group. Aromatic nucleus and side chain structure of benzene : molecular formula and Kekule structure.
Resonance Structure, MO Picture.
Aromaticity : The Huckel rule, aromatic ions Aromatic electrophilic substitution: General Pattern of the mechanism (Nitration, halogenations and Sulphonation) and Friedel Crafts reaction.

## Alkyl and Aryl halides :

Polyhalogen Compounds: Chloroform, Carbon tetrachloride. Methods formation of aryl halides, nuclear and side chain reaction.

## Alcohols :

Definition: *Monohydric Alcohols:* Methods of Formation by reduction of Aldehydes, Ketones, Carboxylic Acids and Esters (one e.g. each) Acidic Nature, Reactions of Alcohols.
*Dihydric Alcohols:* Method of Formation of Ethylene Glycol-industrial method and From Alkenes using Oso4, Chemical Reactions of Ethylene Glycolnitration,
Acylation, Oxidation (Using Pb (OAc)4 without Mechanism Pinacol-Pinacolone rearrangement, *Trithydric Alcohols:* Preparation of Glycerol from propane, Reactions of Glycerol.

## Phenols :

Preparation of Phenol from Cholorobenzene, Cumene and Benzene Sulphonic Acid, Physical properties, Acidic Nature of Phenol, Resonance stabilization of Phenoxide Ion. Reactions of Phenols-Electrophilic Aromatics Substitution, Acylation, Carboxylation (Without Mechanism) Reactions with Mechanism-intermolecular Fries Rearrangement, Claisen Rearrangement, Gattermann Synthesis and reamer Tiemann Reaction.

## Aldehydes and Ketones :

*Aldehydes:* Preparation of Aldehydes from Acid Chloride, Gattermann-Koch Synthesis *Ketones*-Preparation from Nitriles and from Carboxylic Acid, Physical Properties of Aldehydes and Ketones. Mechanism of Nucleophilic Additions to Carbonyl Group with particular emphasis on Benzoin, Aldol Knoenenagel condensations, Mannich Reactions. Use of Acetals as Protecting Group. Oxidation of Aldehydes using Chromium Trioxide, Baeyer-Villeger Oxidation of Ketones.

## Carboxylic Acids :

Acidity of Carboxylic Acids, Effects of substituent's of substituents on Acid strength, preparation of Acetic Acid from Co2 from Nitriles, from Acid Chloride, Anhydride, Ester and Amide. Physical Properties and reactions of Carboxylic Acids-Synthesis of Acid Chloride, Ester and Amide, Hell-Volhard-Zelinsky Reaction. Reduction using LiAIH4, Mechanism of Decarboxylation, hydroxyl Acids-Malic, Tartaric and Citric Acid. Methods of Formation and Chemical reactions of Acrylic Acid.

## Organic Compounds of Nitrogen :

Preparation of *Nitroalkanes.* Nitration of Benzene and Their Reduction in Acidic, Neutral and Basic Media. *Amines*-Basicity of Amines, Amine Salt as PTC. Preparation of Alkyl and Aryl Amines (Reduction of Nitro Compounds', Nitriles) Reductive Amination, Hoffmann Bromamide Reactions. Reactions of Amines-Electrophilic Aromatic Substitution in *Aryl amines,* Reactions of Amines with Nitrous Acid.

## Spectroscopy :

Nuclear magnetic resonance (NMR) spectroscopy. Proton magnetic resonance (1H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of PMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1, 2, 2 tribromoethane, ethyl acetate, toluene and Acetophenone. Problems pertaining to the structure elucidation of simple organic compounds using UV, IR and PMR spectroscopic techniques. (Combine and single λ max using woodwordfischer rule)

## Organometallic Compounds :

Organomagnesium - compounds: Alkyl Magnesium halides-ethyl magnesium bromide formation, structure and chemical reactions. Organozinc compounddialkyl zinc formation and chemical reactions, organolithium compound- nbutyllithium formation and chemical reactions.

## Organic Synthesis via Enolates :

Defination, Active methylene compounds, Preparation of Aceto acetic ester, (Claisen condensation with Mechanism), Acidity of alpha hydrogen, properties and reactions involving formation of mono, di and unsaturated carboxylic acids, also synthesis of ketone, di ketone, 4-methyl uracil from acetoacetic ester, ketoenol tautomerism. Preparation of diethyl malonate, properties and reactions involved in alkylation, formation of mono, di and unsaturated carboxylic acids, and also synthesis of aminoacid and barbituric acids from diethyl malonate.

## Fats, oils and detergents :

Natural fats, edible and industrial oils of vegetable origin, manufacture of soyabean oil by solvent extraction method and isolation and uses of essential oils. Types of animals fats and oils and defination of saponification value, iodine value, and acid value. Detergents: Defination, Introduction and preparation of sodium alkyl sulphonate, alkyl benzene sulphonate, and amide sulphonate, (one example each), Cleansing action of detergent.

## Heterocyclic Compounds :

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine. Comparison of basicity of pyridine, piperidine and

pyrrole. Condensed Heterocyles: Introduction, Preparation of Quinoline (Skraups Synthesis), Isoquinoline (Bischler - Napirlaski) and Indole (Fischer indole Synthesis).

## Carbohydrates :

Defination, Introduction and Classification. Monsaccharides-Interconversion of Glucose and Fructose, chain lengthening, chain shortening of aldoses. Conversion of Glucose in to mannose. Determination of openchain structure of glucose & pyranose ring structure of glucose. Mechanism of Mutarotation and Introduction to disaccharides (maltose, sucrose and lactose) and Polysaccharides (Starch and cellulose) without involving structure determination.

## Synthetic Polymers :

Introduction, Classification based on nature of synthesis (without mechanism) with examples. (Addition and condensation polymers). Properties, uses and synthesis of polyvinyl chloride, polyvinyl acetate, polystyrene, polyacrylonitrile, Nylon 6, Nylon 66. Introduction to synthetic and natural rubber, properties, uses and synthesis of Buna N., Neoprene and silicon rubber.

## Synthetic Dyes and Drugs :

Synthetic Dyes - Definition, colour and constitution (electronic concept) of dye, classification based on chemical constitution, synthesis of methyl orange, Congo red, malachite green, crystal violet, Alizarin and indigo dyes. Synthetic Drugs - Defination, introduction, classification of drugs. Properties of ideal drug. Synthesis of chloromycetien, paracetamol, phenacetien, sulphaguainidine.

## Mathematical Concepts :

Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like kx ex, xn, sin x, log x; axima and minima, partial differentiation.

## Gaseous States :

Postulates of kinetic theory of gases, kinetic gas equation, Deduction of Gas Laws : Boyles Law, Charles Law, Grahams Law of diffusion, Avogadro's hypothesis, deviation from ideal behavior, van der Waals equation of state. Critical Phenomena : PV isotherms of real gases.

## Chemicals Kinetics and Catalysis :

Chemical Kinetics and its scope, rate of reaction, factors influencing the rate of reaction - concentration, temperature, pressure, solvent, light, catalyst concentration dependence of rates. Derivation of rate law and characteristics of simple chemical reactions - zero order, first order, second order, Pseudo order, half life. Effect of temperature on rate of reaction. Arrhenius equation, concept of activation energy.

**Catalysis :** Definition, types, and characteristics of catalysis, homogeneous, heterogeneous catalysis - Enzyme catalysis and its application.

## Liquid State :

Intermolecular forces, structure of liquids (a qualitative description). Differnce between solids, liquids and gases. Liquid Crystals: Classification, structure of nematic and cholestric phases.

## Solid State :

Types of solids, Amorphous, crystalline and difference between them, Miller Indices. Laws of crystallography - (i) Law of constancy of interfacial angels (ii)Law of rationality of indices (iii) Law of symmetry. Symmetry elements in crystals. X-ray diffraction by crystals. Derivation of Bragg equation.

## Colloidal State :

Definition of colloids, classification of colloids.
Solids in liquids (sols) : properties - kinetic, optical and electrical; stability of colloids, protective action. Hardy - Schulze Law.
Liquids in liquids (emulsions) : types of emulsions, preparation.
Liquids in Solids (gels) : classification, preparation and properties, general applications of colloids.

## Thermodynamics :

Definition: *of Thermodynamic Terms:* System, Surrounding types of system, intensive and extensive properties. Thermodynamic Process, Concept of heat and work. Work done in reversible and irreversible process, concept of maximum work (Wmax), Numerical Problems.
First law of Thermodynamics: Statement, Definition of Internal energy and Enthalpy.
Heat capacity, heat capacities at constant volume pressure and their relationship. Calculation of W,q, du and dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process, Numerical problems, Hess's law of heat Summation and its application.

## Thermodynamic-II :

*Second Law of Thermodynamics:* Need for the law, different statement of the law Carnot Cycle and its efficiency, Numerical Problems. Carnot Theorem. Concept of Entropy: Definition, Physical significance, Entropy as a State Function, Entropy change in Physical change, Entropy as criteria of Spontaneity & Equilibrium Entropy Change in Ideal Gases. Gibbs and Helmholtz Functions: Gibbs Function (G) and Helmoltz Function (A) as Thermodynamic Quantities. A and G as criteria for Thermodynamic Equilibrium and Spontaneity, their Advantage over Entropy change.

## Chemical Equilibrium :

Equilibrium Constant and Free Energy. Thermodynamic Derivation of Law of Mass Action. Le Chatelier's Principle. Reaction Isotherm and Reaction Isochore. Clapeyron Equation, Clausius-Clapeyron Equation and its Application.

## Phase Equilibrium :

Statement and Meaning of the Terms*: Phase, Component,* Degree of Freedom, Derivation of Phase Rule Equation. Phase Equilibria of the One Component System: Water System. Phase Equilibria of Two Components System: Solid-Liquid Equilibria, Simple Eutectic Pb-Ag. System Desilverisation of Lead. Solid Solutions: Compound Formation with congruent Melting Point (Mg-Zn) and Incongruent Melting Point ($FeCl_3$-$H_2O$) System. Freezing Mixture, Acetone-Dry Ice.

Liquid-Liquid Mixture: Raoult's Law and Henry's Law. Ideal and Non-Ideal system. Azeotropes: HCl-$H_2O$ and Ethanol-Water System. Partially Miscible Liquids: Phenol-Water, Trimethyl Amine-Water, Nicotinewater System, Lower and Upper consulate Trimethyl Amine-Water, Nicotinewater system, Lower and Upper Consulate Temperature. Effect of Impurity on Consulate Temperature.

## Electro Chemistry-I :

Electrical Transport: Conduction in metals and in Electrolyte Solutions. Specific Conductance and equivalent conductance, measurement of equivalent conduction, variation of equivalent and specific conductance with dilution. Numerical problems. Kohlrausch's law and its application. Arrhenius Theory of Electrolyte Dissociation and its limitations. Weak and Strong Electrolytes, Ostwald's Dilution Law, its use and Limitations. Transport Number: Definition, Determination by Hittorfs Method and Moving Boundary Method. Conductometric Titration: Types and its advantages.

## lectrochemistry-II :

Types of Reversible Electrodes: Gas- Metal Ion, Metal-Metal Ion, Metal-Insoluble salt Anion and Redox Electrodes. Nernst Equation, Derivation of Cell, E.M.F. and single Electrode potential, Standard Hydrogen Electrode, Reference Electrodes, Standard Electrode Potential, Sign Conventions, Electro-Chemical Series and its significance. Electrolytic and Galvanic Cells, Reversible and Irreversible Cells, Conventional Representation of Electro Chemical Cells. E.M.F. of a cell and its measurement, Calculation of Thermodynamic Quantities of Cell Reactions (G, H and K) Definition of pH, pKa-Determination of pH using SHE and Glass Electrode by Potentiometer method. Buffer-Acidic and Basic Buffers, Mechanism of

Buffer Action, Henderson-Hasselbalch equation. Corrosion: Dry (Atmospheric) Corrosion and Wet (Electro-Chemical) Corrosion Electrochemical Theory of Corrosion.

## Elementary Quantum Mechanics :

Black body radiation, Planck's radiation law, photoelectric effect, Bohr's modes of hydrogen atom (no derivation) and its defects. Compton effect. De Broglie Hypothesis, the Heisenberg's uncertainty principles, Harmiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance.

## Spectroscopy :

Introduction - Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation. Rotational Spectrum - Diatomic molecules, energy levels of a rigid rotor (semi-classical principles), selection rule, rotational spectra of rigid diatomic molecule, determination of bond length, numerical problems.

## Photochemistry :

Introduction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry, Grothus - Drapper law, Stark-Einstein law, Jablonsiki diagram qualitative description of fluorescence, phosphorescence, non-radiative processes (Internal conversion, Intersystem crossing), quantum yield, photosensitized reactions.

## Physical properties and molecular structure :

Optical activity and its measurement, dipole moment and its measurement by temperature change method, magnetic property and its measurement by Guoy balance method, Applications of optical activity, dipole moment and magnetic property for determination of structure of molecule.

## Nano Material :

Introduction to nano-materials Methods of Synthesis - i) High energy ball milling, ii) Physical vapour deposition (PVD) iii) Chemical vapour deposition (CVD) iv) Micro emulsion. Synthesis using micro-organisms and plant extract.