RAMAKRISHNA MISSION VIDYAMANDIRA

BELURMATH, HOWRAH, WEST BENGAL

DEPARTMENT OF CHEMISTRY

PROGRAMME OFFERED : B.Sc. CHEMISTRY HONOURS

PROGRAMME CODE : CEMA

DURATION : 6 SEMESTERS

TOTAL CREDIT : 148

FULL SYLLABUS WITH COURSE OUTCOME

VALID & ONGOING AS ON 30TH JUNE, 2019

Following is the credit distribution for B.Sc. Chemistry Hons. Programme:

	CR	CR	CR	CR	CR	CR	Total Credit
	SEM 1	SEM 2	SEM 3	SEM 4	SEM 5	SEM 6	
Core Course / Hons.	14	14	14	14	26	26	**108**
Generic Elective	6	6	6	6	--	--	**24**
AECC-Lang.	2	2	2	2	--	--	**4**
AECC-ENVS	--	--	--	--	--	--	**4**
SEC- ICSH	1	1	1	1	2	2	**8**
	23	**23**	**23**	**23**	**28**	**28**	**148**

Following is the Grade Point distribution:

% of Marks	Descriptor	Grade	Grade Point
85 - 100	OUTSTANDING	**O**	**10**
70 - 84.99	EXCELLENT	**A+**	**9**
60 - 69.99	VERY GOOD	**A**	**8**
55 - 59.99	GOOD	**B+**	**7**
50 - 54.99	ABOVE AVERAGE	**B**	**6**
40 - 49.99	AVERAGE	**C**	**5**
35 - 39.99	PASS (HONOURS)	**P**	**4**
30 - 34.99	PASS (OTHERS)	**P**	**4**
LESS THAN 35	FAILED (HONOURS)	**F**	**0**
LESS THAN 30	FAILED (OTHERS)	**F**	**0**

Name of the Core Course	Credit for the Core Course	Generic Elective Course and the Credit
Chemistry Hons	108	Total Credit : 24 At present, considering the future prospect of the students the college offers following two Generic Elective subjects Courses for all students of this Hons programme: a) Mathematics & b) Physics

B.Sc. Chemistry Hons. Programme has introduced Discipline Specific Elective Course (DSE) and/or Project in 5h and/or 6th semester:

Sl. No.	Name of the Programme	Discipline Specific Elective / Project
1	Chemistry Hons	Project

Students of B.Sc. Chemistry Hons. Programme must take following courses :

- Ability Enhancement Compulsory Courses (AECC):
  - Environmental Science : 4 Credit
  - English Language and MIL (Bengali Language/ Alternative English) : 4 Credit
- Value-Oriented Course (Indian Cultural and Spiritual Heritage) : 8 Credit

Total Credit to be earned by a student to complete B.Sc. Chemistry Hons. Programme: 148 Credit
Mark sheet after each semester will be given both with SGPA and detailed marks obtained by the examinee.
Similarly Mark sheet after the final semester will be given with CGPA and detailed marks obtained by the examinee.

Calculation of SGPA = (Total Credit X Total Grade Point = Total Credit Point); Total Credit Points / Total Credits
Calculation of CGPA = (Total SGPA X Total Credits in each Sem.) / Total Credits earned in all the Semesters

B.Sc. Chemistry Honours
6 Semester Course
Course Structure

Sl No	Name of the Course	Semester	Course Code	Credit	Marks in the Course	Course outcome
1	Organic chemistry-I, Physical Chemistry-I, Inorganic Chemistry-I (theory)	1	CEMA-P1-T	10	75	• Description of macroscopic gas behaviour including the distribution of velocities • Ideal gas model, real gas model – success and limitations deal gas model, real gas model – success and limitations • Foundation of thermodynamics and different processes and transformation of energies • Concept of shape of different orbital and term symbols; Concept of shape of different orbital and term symbols • Estimate standard reaction enthalpy by various means • Concept of IP, EA and various scale of electro negativity • Concept of various type of crystal defect in ionic solids • Concept of physical properties (dipole moment, mp/bp, acidity and basicity)

						• Concept of molecular orbital • Concept of chirality and stereochemistry
2	Organic chemistry-I(Practical)	1	CEMA-P1-P **New Course vide Dated 02.07.2016**	4	25	• Qualitative analysis of organic compounds
3	Organic chemistry-II, Physical Chemistry-II, Inorganic Chemistry-II (theory)	2	CEMA-P2-T	10	75	• Origin of spontaneity of chemical and physical processes and concept of entropy • Two other thermodynamic properties – A and G, to express spontaneity and equilibrium • Reaction rate laws and its dependence on factors like concentration, temperature etc • Concepts of reaction mechanism and theories for reaction rate - Collision theory and TST • Reaction pathway and progression (theoretical and practical aspect) • Type of reactions and mechanism • Concept of hybridization and shape of molecules/ions • Concept of nuclear model • Concept of lattice energy and its application

4	Inorganic Chemistry -I (Practical)	2	CEMA-P2-P	4	25	• Qualitative analysis of inorganic single salt
5	Organic chemistry-III, Physical Chemistry-III, Inorganic Chemistry-III (theory)	3	CEMA-P3-T	10	75	• Thermodynamic conditions for chemical equilibrium • Applications of La Chatelier's Principle, vant' Hoff Isotherm • Requirement of quantum mechanics with the limitations of classical physics • Operator algebra, Schrodinger equation for simple model system and quantization • Reactivity of carbonyl compounds • Study of aromatic compounds • Diels-Alder reaction to get cyclic molecules • Concept of various acid-base theory and acid-base titration curves • Redox and formal potential, feasibility of reaction and Redox potential diagram • Concept of Molecular orbital and bonding
6	Inorganic Chemistry-II (Practical)	3	CEMA-P3-P **New Course vide Dated 02.07.2016**	4	25	• Concept of analysis of inorganic salt mixture
7	Organic chemistry-IV, Physical Chemistry-IV, Inorganic Chemistry-IV (theory)	4	CEMA-P4-T	10	75	• Concept of activity and the effect of ion-ion interactions towards the electrolytic solutions • Nature of migration of ions in electrolytic solution in the presence of an electric field • Electrochemical cell, thermodynamic properties of cell reaction, Nernst equation • Application of concept of EMF to the analysis of potentiometric titration • Quantum mechanical solution of some basic mode of motions - vibration and rotation • Concept of generation of s, p d orbitals from quantum mechanical solutions • Use of organometallic compounds

						in organic synthesis • Study of aromatic and nitrogen containing compounds • Designing organic synthesis through disconnection approach • Concept of oxidation state, hydride, halide - their group trends • Concept of oxo and peroxo compound • Concept of separation of various ions (cations and anions) • Concept of polymeric compounds • Knowledge of various type of reaction of different elements
8	Physical Chemistry-I(Practical)	4	CEMA-P4-P	4	25	• Experimental elucidation of conductometric titration to evaluate important physical parameter • Experimental understanding of kinetic behavior of chemical reaction.
9	Physical Chemistry-V (theory)	5	CEMA-P5-T	6	50	• Understanding of crystal lattice and the basic principle of X-ray diffraction • Electrical properties like dipole moment and polarizability of the molecules • Explanation of surface and interfacial phenomenon and general idea about colloidal particles and self-associating systems • The effect of solute on thermodynamic properties of a solution • Understanding of phase diagram of matter and the role of thermodynamic parameters on the equilibrium between phases • Description of the relationship between microscopic and bulk properties of matter • Concept of partition function and its relationship to different thermodynamic properties • Concept of statistical thermodynamics in calculating chemically significant quantities like residual entropy and heat capacities • Attainment of zero Kelvin and adiabatic demagnetisation

10	Organic chemistry-V, (theory)	5	CEMA-P6-T	5	50	• Methodologies for synthesis of chiral and heterocyclic molecules • Synthesis and use of common drugs • Synthesis of amino acids and peptides, including Merrifield synthesis • Structure elucidation by modern spectroscopy
11	Inorganic Chemistry-V (theory)	5	CEMA-P7-T	5	50	• Concept of crystal field stabilization energy and Orgel diagram • Concept of Homogeneous and heterogeneous catalysis by organometallic compounds • Concept of EAN and 18-electron rule • Chemistry of some typical Bio-molecules related to life processes
12	Physical chemistry-II, Organic Chemistry -II (Practical)	5	CEMA-P8-P	10	65	• Determination of important physical parameter using potentiometer • Experimental elucidation of properties of liquids such as viscosity and surface tension • Laboratory synthesis of organic molecules
13	Organic chemistry-VI, Physical Chemistry-VI, (Theory)	6	CEMA-P9-T	8	50	• Concepts of photochemical and photophysical processes with theoretical models and correlation with experimental methods to investigate photochemical reactions • Understanding molecular spectra - including rotational, vibrational and electronic spectra and recognizing relationship between molecular properties and molecular spectra • Study of Bio-molecules • Advance level separation technique • Study of natural products • Pericyclic reactions

14	Analytical Chemistry-I, Inorganic Chemistry-VI (theory)	6	CEMA-P10-T	8	50	• Concept of complexometric, permanganometric, argentometric titrations • Concept of co-precipitation and post precipitation • Concept of Errors in chemical analysis • Analysis of water, soil and air sample • Concept of magnetic and spectral properties of Lanthanides and Actinides elements • Basic idea of nano technology
15	Analytical Chemistry-I, Organic Chemistry-III, Physical Chemistry-III, Inorganic Chemistry-III (Practical)	6	CEMA-P11-P	10	85	• Estimation of complex bio molecules such as amino acids and vitamin • Experimental analysis of ore and alloy • Experimental analysis of synthesized organic molecules by modern spectroscopy • Separation of organic molecules from a mixture employing coloumn and thin layer chromatography • Application of Spectrophotometry to study reaction kinetics • Experimental elucidcation of thermodynamics of liquid mixtures • Estimation of individual metal ions and metal ions in mixture spectrophotometrically and titrimetrically

B.Sc. Chemistry Honours
6 Semester Course
Mapping of Employability etc.

Sl No	Name of the Course	Semester	Course Code	
1	Organic chemistry-I, Physical Chemistry-I, Inorganic Chemistry-I (theory)	1	CEMA-P1-T	• Students learn here the principle of basic chemistry. This knowledge is directly useful in determining energy content of various useful substances like fuel or food, therefore might be helpful to the students in procuring jobs in industries related to food, fuel etc. Take home assignments are given.
2	Organic chemistry-I(Practical)	1	CEMA-P1-P	• Students learn to detect functional groups in organic sample through mock test and internal assessments.
3	Organic chemistry-II, Physical Chemistry-II, Inorganic Chemistry-II (theory)	2	CEMA-P2-T	• Students learn the fundamentals of reaction kinetics and catalysis. Such knowledge may enable a student to be employed in a production sector that requires catalytic conversion like biotech or pharmaceuticals companies.
4	Inorganic Chemistry -I (Practical)	2	CEMA-P2-P	• Students learn to detect ions in a mixture; this skill helps them to be employed in chemical industries or in detection of heavy metals in soil/water etc. They are skilled to handle hazardous chemical.

5	Organic chemistry-III, Physical Chemistry-III, Inorganic Chemistry-III (theory)	3	CEMA-P3-T	• The students learn the procedure and mechanism of aromatic substitution and how this can be applied towards synthesis of compounds such as paracetamol or aspirin. This would make the students employable in medicinal enterprises.
6	Inorganic Chemistry-II (Practical)	3	CEMA-P3-P	• Students learn to detect ions in a mixture; this skill helps them to be employed in chemical industries or in detection of heavy metals in soil/water etc.
7	Organic chemistry-IV, Physical Chemistry-IV, Inorganic Chemistry-IV (theory)	4	CEMA-P4-T	• The course includes properties and synthesis of aromatic nitro compounds which enables student to work in chemical industries, concept of retrosynthesis which is essential for designing synthesis of organic molecules. The course includes a unit on electrochemistry, the knowledge is necessary for working on fuel cells or in designing corrosion controls.
8	Physical Chemistry-I(Practical)	4	CEMA-P4-P	• Students learn to measure pH, such knowledge is essential in analysing pathological samples like blood, urine or for testing quality of water, soil, food, medicine etc.
9	Physical Chemistry-V (theory)	5	CEMA-P5-T	• The unit on surface science provides a basis to work in chemical plants designing storage devices, heterogeneous catalysis.
10	Organic chemistry-V, (theory)	5	CEMA-P6-T	• The students gets acquainted with spectroscopic methods of identifying functional groups/organic compounds, these are the modern tools employed in forensic studies. The unit on heterocyclic chemistry includes synthesis, uses and action of common drugs like Nifedipine, amlodipine, ranitidine, chloroquine. These would help the students working in the medicinal industries.

11	Inorganic Chemistry-V (theory)	5	CEMA-P7-T	• The students get idea about the importance of ligands to contol magnetic and optical properties. Seminars are regularly arranged on the specilized field.
12	Physical chemistry-II, Organic Chemistry -II (Practical)	5	CEMA-P8-P	• Students learn to measure surface tension, viscosity of liquids which is required in industries preparing food, adhesives, cosmetics, oil and pharmaceuticals petrochemical industries. The department arranged regularly industrial visit for students for better industrial exposure.
13	Organic chemistry-VI, Physical Chemistry-VI, (Theory)	6	CEMA-P9-T	• The students get acquainted with advance level separation technique which will be helpful for research carrier.
14	Analytical Chemistry-I, Inorganic Chemistry-VI (theory)	6	CEMA-P10-T	• Analytical chemistry part contains principle of basic analytic tools like gravimetric analysis, estimation of ore , cement, alloys, EDTA titration, complexometric, redox, argentometric titrations, analysis of water and air samples , chromatographic techniques and error analysis. Any chemical industry or metallurgical enterprise would require such knowledge.
15	Analytical Chemistry-I, Organic Chemistry-III, Physical Chemistry-III, Inorganic Chemistry-III (Practical)	6	CEMA-P11-P	• Students get hand on experience on estimation of ore, cement, alloys, water samples and chromatographic techniques.
16	General Chemistry , Physical Chemistry	1	CEMG-P1-T	• Students learn here the principle of basic chemistry. Lab quiz and viva are regularly taken to keep students updated.
17	Organic Qualitative Analysis	1	CEMG-P1-P	

18	Inorganic Chemistry, Organic Chemistry	2	CEMG-P2-T	Lab quiz and surprise tests are taken to examine the skill and knowledge students acquired.
19	Quantitative Analysis of inorganic sample(s) Qualitative Analysis of Single Inorganic Compound	2	CEMG-P2-P	
20	Inorganic Chemistry	3	CEMG-P3-T	• Students learn here the stability of complex and their availability in nature. Career consultation via arrnaging seminars.
21	Systematic Qualitative analysis of unknown mixture of solid inorganic salts	3	CEMG-P3-P	
22	General Chemistry, Organic Chemistry, Physical Chemistry	4	CEMG-P4-T	Take home assignments are given.

SEMESTER 1

CEMAP1t [75 MARKS]

Course outcome:

- **Description of macroscopic gas behavior including the distribution of velocities**
- **Ideal gas model, real gas model – success and limitations**
- **Foundation of thermodynamics and different processes and transformation of energies**
- **Concept of shape of different orbital and term symbols**
- **Estimate standard reaction enthalpy by various means**
- **Concept of IP, EA and various scale of electro negativity**
- **Concept of various type of crystal defect in ionic solids**

- **Concept of physical properties (dipole moment, mp/bp, acidity and basicity)**
- **Concept of molecular orbital**
- **Concept of chirality and stereochemistry**
- **Qualitative analysis of organic compounds**

Group A *[40 MARKS]*

ORGANIC CHEMISTRY

UNIT I: Acyclic stereochemistry [15 M – 1 question out of 2 (of marks 15) is to be answered]

Chirality, Symmetry elements, molecular Symmetry and Chirality, optical activity of chiral compounds, specific rotation, enantiomers and diastereomers, representation of molecules having one, two and three chiral centres Flying-Wedge, Fischer, Newman and Sawhorse formulas and their inter-translations. Threo and Erythro designation. Definition of configuration and conformation D/L, R/S, cis/trans, syn/anti, E/Z (C = C, C = N) stereochemical nomenclature.

Stereogenicity, chirotopicity and pseudoasymmetric centres. Optical purity, enantiomeric excess, racemic modificaiton, racemisation (through cationic and anionic intermediates), resolution of acids, bases, alcohols and carbonyl compounds via diastereomeric salt formation.

Topicity of ligands and faces: Pro-R, Pro-S and Re/Si descriptors.

Stereoaxis: Chiral axis in allenes and biphenyls, R/S designation.

Conformation: Conformational nomenclature; eclipsed, staggered, gauche and anti, dihedral angle, torsional angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, 2-methylbutane, 1,2-haloethane, 1,2-glycol, 1,2-halohydrin, invertomerism of trialkylamines, rotamers.

PHYSICAL CHEMISTRY

UNIT II: Kinetic theory and the gaseous state [13 M – 1 question out of 2 (of marks 13) is to be answered]

Concept of pressure and temperature. Nature of distribution of velocities in one, two and three dimensions. Maxwell's distribution of speeds. Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Collision of gas molecules; collision diameter; collision number and mean free path; frequency of binary collisions (similar and different molecules); wall collision and rate of effusion. Viscosity of gases.

Deviation of gases from ideal behaviour; compressibility factor; Andrew's and Amagot's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state and significance of second virial coefficient. Boyle temperature. Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea).

UNIT III: Thermodynamics – I [12 M – 1 question out of 2 (of marks 12) is to be answered]

Importance and scope, definitions of system and surroundings; type of systems (isolated, closed and open). Extensive and intensive properties. Concept of Steady state and Equilibrium state. Concept of thermal equilibrium and the zeroth-law of thermodynamics. Thermodynamic coordinates, state of a system, equation of state, state functions and path functions. Partial derivatives and cyclic rule. Concept of heat and work (IUPAC convention). Graphical explanation of work done during expansion and compression of an ideal gas. Reversible and irreversible processes and work done.

First law of thermodynamics, internal energy (U) as a state function. Enthalpy as a state function. Heat changes at constant volume and constant pressure; relation between C_P and C_V using ideal gas and van der Waals equations. Joule's experiment and its consequence. Explanation of term $(\delta U/\delta V)T$. Isothermal and adiabatic processes.

Thermochemistry: heat changes during physicochemical processes at constant pressure/volume. Kirchoff's relations. Bond dissociation energies. Changes of thermodynamic properties in different chemical changes.

Group B ***[35 MARKS]***

ORGANIC CHEMISTRY

UNIT I: Bonding and physical properties [10 M– 1 question out of 2 (of marks 10) is to be answered]

Mechanistic classification: ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism.
Valence bond theory: concept of hybridisation, resonance (including hyperconjugation), orbital pictures of bonding (sp^3, sp^2, sp: C=C, C=N & C=O system).Inductive effect, bond polarization and bond polarizability, steric effect, steric inhibition of resonance.

MO theory: sketch and energy levels of MOs of (i) acyclic p orbital system (C=C, conjugated diene and allyl systems), (ii) cyclic *p* orbital system (neutral system: [4], [6], [8], [10] [12], [14], [18] annulenes; charged system: 3,4,5, 7, 8-ring system); Frost diagram* (*polygon-and-circle diagram predicting relative energies of monocyclic conjugated alkenes), Huckel's rules for aromaticity & antiaromaticity; homoaromaticity. (acidity on the basis of aromaticity)

Physical properties: bond distance, bond angles, mp/bp & dipole moment in terms of structure and bonding (covalent & non covalent). Heat of hydrogenation and heat of combustion.

INORGANIC CHEMISTRY

Unit-II: Atomic Structure [9M] 1 question out of 2 is to be answered
Bohr's theory of hydrogen-like atom and ions; spectrum of hydrogen atom. Quantum numbers. Introduction to the concept of atomic orbitals; shapes, radial and angular probability diagrams of s, p and d orbitals (qualitative idea). Many electron atoms and ions: Pauli's exclusion principle, Hund's rule, Term symbols of atoms and ions for atomic numbers < 30.

Unit-III: Chemical periodicity I [8 M] 1 question out of 2 is to be answered
Effective nuclear charges, Exchange energy, elementary idea on Relativistic effect, Screening effects, Slater's rules, atomic radii, ionic radii (Pauling's univalent radii), covalent radii. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales). Group trends and periodic trends of these properties in respect of s-, p- and d-block elements and factors influencing these properties.

Unit-IV: Chemical periodicity II [8 M] 1 question out of 2 is to be answered
Inert pair effect. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. Group trends and periodic trends in physical properties. Modern IUPAC Periodic table. General characteristic of

s, p, d and f block elements. Solvation energy, polarizing power and polarizability, ionic potential, Fajan's rules. Defects in solids: Schottky defect, Frenkel defect, Metal excess defect, Metal deficiency defect, (elemementary idea and example only).Partial ionic Character of covalent bonds, bond moment, dipole moment and electronegativity differences. Concept of resonance, resonance energy, resonance structures and calculation of formal charges.

CEMAP1p [25 MARKS]

Practical (25 M)

Experiment -1. Qualitative analysis of single solid organic compounds

A. Detection of special elements (N, Cl, S) by Lassaigne's test

B. Solubility and Classification (solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)

C. Detection of the following functional groups by systematic chemical tests:
Aromatic amino ($-NH_2$), aromatic nitro ($-NO_2$), Amido ($-CONH_2$, including imide), Phenolic –OH, Carboxylic acid (-COOH), Carbonyl (>C=O and –CHO); only one test for each functional group is to be reported.

Demonstration experiment:

(i) Fiegel test of $-CO_2R$
(ii) Derivatives preparations(at least *two*) ($-CO_2H$, >C=O, hydrolysis of $-CONH_2$)

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown (at least 5) organic compounds.

SEMESTER 2

CEMAP2t [75 MARKS]
Revision vide Dated 25.07.2015

Course outcome:

- **Origin of spontaneity of chemical and physical processes and concept of entropy**
- **Two other thermodynamic properties – A and G, to express spontaneity and equilibrium**
- **Reaction rate laws and its dependence on factors like concentration, temperature etc**
- **Concepts of reaction mechanism and theories for reaction rate - Collision theory and TST**
- **Reaction pathway and progression (theoretical and practical aspect)**
- **Type of reactions and mechanism**
- **Concept of hybridization and shape of molecules/ions**

- **Concept of nuclear model**
- **Concept of lattice energy and its application**
- **Qualitative analysis of inorganic single salt**

Group A ***[40 MARKS]***

ORGANIC CHEMISTRY

UNIT I: Nucleophilic substitution, Elimination (aliphatic) and Addition reactions [15 M – 1 question out of 2 (of marks 15) is to be answered]

Substitution at sp^3 centre - Mechanism: S_N1, S_N2, S_N2', S_N^i mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP; relative rate & stereochemical features, [systems: alkyl halides, allyl halides, benzyl halides, bridged systems, alcohols, ethers, epoxides].

Elimination - Mechanisms: E1, E2 and E1cB; reactivity, orientation (Saytzeff/Hofmann) and stereoselectivity; substitution vs elimination.

Electrophilic addition to C=C: Mechanism, reactivity, regioselectivity and stereoselectivity. Reactions: hydrogenation (H_2/metal cat,Wilkinson's cat, hydroboration-AcOH, HN=NH, cyclohexene/Pd cat.), hydrohalogenation (Markonikov addition, peroxide effect for HBr only, addn. to alkenes containing CF_3, NO_2, Cl, OMe etc., rearrangement of carbocations), halogenations (simple alkenes, stereospecificity, loss of stereoselectivity for alkenes containing Ar gr.), hydration (H_3O^+, hydroboration-peroxidation, disiamylborane, regioselectivity of hydroboration, oxymercuration-demercuration), epoxidation (Prilezhaev reaction. via halohydrin, of α,β-unsaturated carbonyl), hydroxylation (OsO_4-oxidants, $KMnO_4$-alkali, halohydrin-mild alkali, hydrolysis of epoxide, Prevost method), cleavage of diol by HIO_4, $Pb(OAc)_4$, ozonolysis.

PHYSICAL CHEMISTRY

UNIT II: Thermodynamics – II [12 M – 1 question out of 2 (of marks 13) is to be answered]

Second law of thermodynamics – need for a Second law. Concept of heat reservoirs and heat engines. Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation. Carnot cycle and refrigerator. Carnot's theorem; thermodynamic scale of temperature.

Physical concept of entropy. Entropy as a measure of the microscopic but not macroscopic disorder. Values of §dQ/T and Clausius inequality. Entropy change of systems and surroundings for various processes and transformations. Entropy change during the isothermal mixing of ideal gases.

Entropy and unavailable work. Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium. Thermodynamic relations: Maxwell's relations, thermodynamic equation of state. Gibbs- Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature. Joule-Thomson coefficient for a van der Waals gas. General heat capacity relations.

UNIT III: Chemical Kinetics and Catalysis [13 M – 1 question out of 2 (of marks 13) is to be answered]

Introduction of reaction rate in terms of extent of reaction; rate constants, order. First order, second order and n-th order reactions. Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate).

Determination of order of a reaction by half-life and differential method. Temperature dependence of rate constant: Arrhenius equation, energy of activation.

Rate-determining and steady-state approximation – explanation with suitable examples. Opposing reactions, consecutive reactions and parallel reactions (with explanation of kinetic and thermodynamic control of products; all steps first order).

Collision theory (detailed treatment); outline of Transition State theory. Lindemann theory of unimolecular reaction.

Catalysis: Homogeneous catalysis with reference to acid-base catalysis, Primary kinetic salt effect. Autocatalysis. Enzyme catalysis: Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number.

Group B *[35 MARKS]*

ORGANIC CHEMISTRY

UNIT I: Nomenclature ,General treatment of reaction [10 M– 1 question out of 2 of marks 10 is to be answered]

IUPAC nomenclature-acyclic, cyclic, aromatic and other related systems.Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behaviour, stability, generation and fate (elementary idea. Halogenation of alkanes by free radical mechanism, allylic and benzylic halogenation by NBS.

Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factor, intermolecular & intramolecular reactions. Application of thermodynamic principles in tautomeric equilibria (keto-enol tautomerism, composition of the equilibrium in different systems (simple carbonyl, 1,3 and 1,2- dicarbonyl systems, phenols and related system; substituent and solvent effect.

Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.

Reaction kinetics: transition state theory, rate const and free energy of activation, free energy profiles for one step and two step reactions, catalyzed reactions, kinetic control and thermodynamic control of reactions, isotope effect, primary kinetic isotopic effect (k_H/k_D), principle of microscopic reversibility, Hammond postulate.

INORGANIC CHEMISTRY

Unit-II: Radioactivity [8 M] 1 question out of 2 is to be answered

Nuclear stability and nuclear binding energy. Meson exchange theory. Nuclear models (elementary idea): Nuclear Forces, magic numbers. Nuclear spin and nuclear isomerism, Nuclear Reactions: fission, fusion and spallation. Radio chemical methods: Applications of radioactivity, Tracer techniques principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures.

Unit-III: Chemical Bonding and structure [9 M] 1 question out of 2 is to be answered

Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, Ionic solids; lattice energy, Born-lande equation and its applications, Born-Haber cycle and its applications.

Covalent bonding: Valence Bond Theory, directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry),

Unit IV: Chemical Periodicity [8 M] 1 question out of 2 is to be answered]

General trends of variation of electronic configuration, Ionization Energy, Electron Affinity, Hydration Energy (if any), catenation and catalytic properties (if any), oxidation states, aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such as hydrides, halides, Oxo compounds, (if any), complex chemistry (if any) in respect of the following elements:

(i) s-block elements: Li-Na-K-Rb-Cs, Be-Mg-Ca-Sr-Ba.

(ii) Elements of IB and IIB – Cu, Ag, Au; Zn, Cd, Hg

CEMAP2p [25 MARKS]

Practical (25 M)

Analysis of an unknown single compound containing cation and anion

Cation Radicals: Pb^{+2}, As^{3+}, Hg^{2+}, Bi^{3+}, Cu^{+2}, Cd^{+2}, Sb^{+3}, Fe^{+3}, Al^{+3}, Cr^{+3}, Zn^{+2}, Ni^{+2}, Co^{+2}, $Mn^{+2/+4}$, Ca^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}

Anion Radicals: F^{-}, Cl^{-}, Br^{-}, I^{-}, BrO_3^{-},IO_3^{-} SCN^{-}, NO_2^{-}, NO_3^{-}, S^{-2}, SO_4^{-2}, $S_2O_3^{-2}$, PO_4^{-3}, BO_3^{-3}, H_3BO_3, $CrO_4^{-2}/Cr_2O_7^{-2}$, $Fe(CN)_6^{-4}$, $Fe(CN)_6^{-3}AsO_4^{3-}$, AsO_3^{3-}

SEMESTER 3

CEMAP3t [75 MARKS]

Course outcome:

- **Thermodynamic conditions for chemical equilibrium**
- **Applications of La Chatelier's Principle, vant' Hoff Isotherm**
- **Requirement of quantum mechanics with the limitations of classical physics**
- **Operator algebra, Schrodinger equation for simple model system and quantization**
- **Reactivity of carbonyl compounds**
- **Study of aromatic compounds**
- **Diels-Alder reaction to get cyclic molecules**
- **Concept of various acid-base theory and acid-base titration curves**
- **Redox and formal potential, feasibility of reaction and Redox potential diagram**

- **Concept of Molecular orbital and bonding**
- **Concept of analysis of inorganic salt mixture**

Group A ***[40 MARKS]***

ORGANIC CHEMISTRY

UNIT I: Chemistry of Alkynes, Dienes, Carbonyl compounds, Carboxylic acids and their derivatives [15 M – 1 question out of 2 (of marks 15) is to be answered]

A. Alkynes: Alkynic C-H cleavage ,halogenation, hydration (acid-catalysed-Hg^{+2}, hydroboration-peroxidation using Sia_2BH) of alkynes, dissolving metal reduction of alkynes and bezenoid aromatics (Birch).

B. Dienes: **(i) Electrophiilic addition:** 1,2-, 1,4-additions, hydration, halogenation, HX addition of conjugated dienes and allenes.
(ii) Pericyclic reactions –I: Cycloaddition reactions, FMO approach, Diels- Alder reaction, photochemical [2+2] reactions.

C. Carbonyl compounds: Nucleophilic addition to C=O: Mechanism, reactivity, Reactions with HCN, sodiumbisulfite, NH_2Z, Nitrosation, reactions with SeO_2, Carbonyl Reduction: hydride addition, M.P.V. reduction, DIBAL-H, Wolff-Kishner reduction, Clemmensen Reduction, Cannizzaro reaction, Tischenko reaction, aldol condensation, Knoevenagel reaction, benzoin condensation, halogenation of carbonyls, Mannich reaction, enamines, E. Clarke methylation, Mcmurry reaction, Stobbe condensation, Natural reactivity and umpolung, protection of carbonyls-acetals, thioacetals, Perkin reaction, reaction with nitromethane.

Nucleophilic addition to α,β-unsaturated carbonyl system (general principles, equilibrium and kinetic control).

D: Carboxylic acids and their derivatives: Nucleophilic substitution at the acyl carbon of acyl halides, anhydrides, amides, tetrahedral mechanism, esterification and ester hydrolysis ($A_{AC}2$, $A_{AC}1$, $A_{AL}1$, $B_{AC}2$, $B_{AL}1$, $B_{AL}2$), nitriles and isonitriles hydrolysis, amide hydrolysis, conversion of acid into acid chloride, HVZ reaction, Hunsdiecker reaction, Carbanions-alkylation of ester using LDA , LICHA., Claisen ester condensation, dissolving metal reduction (Bouveault-Blanc reduction of ester) Acyloin condensation. Decarboxylation of carboxylic acids, action of heat on α, ² and ³-hydroxy acids.

PHYSICAL CHEMISTRY

UNIT II: Thermodynamic Equilibrium [12 M – 1 question out of 2 (of marks 12) is to be answered]

Chemical potential and activity, partial molar quantities, chemical potential in terms of Gibb's free energy and other thermodynamic state functions and its variation with temperature and pressure.

Thermodynamic conditions for equilibrium, degree of advancement. van't Hoff's reaction isotherm (deduction from chemical potential). Variation of free energy with degree of advancement. Equilibrium constant and standard Gibbs free energy change. Definitions of K_P, $K_C$and K_X; van't Hoff's reaction isobar and isochore from different standard states. Shifting of equilibrium due to change in external parameters e.g. temperature and pressure. Le Chatelier's principle. Nernst distribution law. Application- (finding out K_{eq} using Nernst dist law for $KI+I_2 = KI_3$ and dimerization of benzene, Solvent extraction.

UNIT III: Quantum Chemistry – I [12 M – 1 question out of 2 (of marks 12) is to be answered]

Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators. Commutation of operators, commutator and uncertainty relation (without proof). Expectation value. Hermitian operator. Schrodinger time-independent equation: nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function.

Particle in a box: setting up of Schrodinger equation for one-dimensional box and its solution. Comparison with free particle eigenfunctions and eigenvalues. Properties of PB wave functions (normalisation, orthogonality, probability distribution). Expectation values of x, x^2, p_x and p_x^2 and their significance in relation to the uncertainty principle. Extension of the problem to two and three dimensions and the concept of degenerate energy levels.

Group B ***[35 MARKS]***

ORGANIC CHEMISTRY

Unit I. Aromatic substitution [10 M– 1 question out of 2 (of marks 10) is to be answered]

Electrophilic aromatic substitution: Mechanisms, orientation and reactivity., ipso substitution.

Reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reactions, Gattermann reaction, chloromethylation.

Nucleophilic aromatic substitution: S_N2(aromatic), benzyne- cine substitution

Reactions of phenols: Reimer-Tiemann, Kolbe-Schmidt, Mannasse (introduction of $–CH_2OH$), Vilsmeier-Haack, halogenation, oxidative coupling by Fe^{+3}, Houben-Hoesch reaction. Synthesis and uses of paracetamol and aspirin.

Reactions of quinones: HCl, $PhNH_2$, $KCN-H_2SO_4$, Thiele acetylation, Diethyl malonate

INORGANIC CHEMISTRY

Unit II: Acid-Base reactions [8M] 1 question out of 2 is to be answered

(a) Acid-Base concept: Theory of solvent system (H_2O, NH_3), relative strength of acids, Pauling rules.Amphoterism. Lux-Flood concept, Lewis concept. Superacids, HSAB principle. Acid-base equilibria in aqueous solution and pH. Acid-base neutralisation curves; indicator, choice of indicators.

(b) Coordinate bonding: Werner theory of coordination compounds. Ambidentate, polydentate and flexidentate ligands, chelate complexes and chelate effect, Inner metallic complexes. IUPAC nomenclature of coordination compounds (up to two metal centers) Coordination numbers.

Unit III: Redox Reactions [8M] 1 question out of 2 is to be answered

Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples).

Unit IV: Molecular Orbital Theory [9M] 1 question out of 2 is to be answered

(i) Molecular orbital concept of bonding (elementary pictorial approach):sigma and pi-bonds, multiple bonding, MO diagrams of H_2, F_2, O_2, C_2, B_2, N_2, CO, NO, CN^-, HF, and H_2O, bond orders, bond lengths, Walsh Diagram.

(ii) Hydrogen bonding and its effects on the physical properties of compounds of the main group elements.

Metallic bonding: qualitative idea of band theory, conducting, semi conducting and insulating properties with examples.

CEMAP3p [25 MARKS]

Practical (25 M)

Analysis of an unknown mixture containing four radicals, with composition

Cation Radicals: Pb^{+2}, As^{3+}, Hg^{2+}, Bi^{3+}, Cu^{+2}, Cd^{+2}, Sb^{+3}, Fe^{+3}, Al^{+3}, Cr^{+3}, Zn^{+2}, Ni^{+2}, Co^{+2}, $Mn^{+2/+4}$, Ca^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}

Anion Radicals: F^{-}, Cl^{-}, Br^{-}, I^{-}, BrO_3^{-},IO_3^{-} SCN^{-}, NO_2^{-}, NO_3^{-}, S^{-2}, SO_4^{-2}, $S_2O_3^{-2}$, PO_4^{-3}, BO_3^{-3}, H_3BO_3, $CrO_4^{-2}/Cr_2O_7^{-2}$, Fe $(CN)_6^{-4}$, $Fe(CN)_6^{-3}AsO_4^{3-}$, AsO_3^{3-}

Insoluble Materials: Al_2O_3, Fe_2O_3, Cr_2O_3, $SrSO_4$, $BaSO_4$, PbSO4,

SEMESTER 4

CEMAP4t [75 MARKS]

Course outcome:

- **Concept of activity and the effect of ion-ion interactions towards the electrolytic solutions**
- **Nature of migration of ions in electrolytic solution in the presence of an electric field**
- **Electrochemical cell, thermodynamic properties of cell reaction, Nernst equation**
- **Application of concept of EMF to the analysis of potentiometric titration**
- **Quantum mechanical solution of some basic mode of motions - vibration and rotation**
- **Concept of generation of s, p d orbitals from quantum mechanical solutions**
- **Use of organometallic compounds in organic synthesis**
- **Study of aromatic and nitrogen containing compounds**
- **Designing organic synthesis through disconnection approach**
- **Concept of oxidation state, hydride, halide - their group trends**

- **Concept of oxo and peroxo compound**
- **Concept of separation of various ions (cations and anions)**
- **Concept of polymeric compounds**
- **Knowledge of various type of reaction of different elements**
- **Experimental elucidation of conductometric titration to evaluate important physical parameter**
- **Experimental understanding of kinetic behavior of chemical reaction.**

Group A ***[40 MARKS]***

ORGANIC CHEMISTRY

Unit I. Rearrangements and nitrogen compounds: [15 M – 1 question out of 2 (of marks 15) is to be answered]

A. Rearrangements:
Migration to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demyanov rearrangement, Rupe rearrangement.

Migration to electron-deficient nitrogen :Beckmann, Schmidt, Hofmann, Lossen, Curtius rearrangements.

Migration to electron-deficient oxygen: Baeyer-Villiger oxidation, hydroperoxide rearrangement (cumene hydroperoxide-phenol rearrangement), Dakin reaction.

Rearrangement involving carbanions: Favorskii.

Aromatic rearrangements: von Richter rearrangement, migration from oxygen to ring carbon (Fries rearrangement, Claisen rearrangement); migration from nitrogen to ring carbon (Hofmann-Martius rearrangement**,** Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement (PhNHOH to *p*-$HOC_6H_4NH_2$), Orton rearrangement, benzidine rearrangement.

B. Nitrogen compounds:
amines (aliphatic & aromatic): preparation, separation and identification of primary, secondary and tertiary amines, Hofmann-exhaustive methylation, diazomethane, diazoacetic ester, nitroalkanes, alkyl nitrites, nitrile and isonitrile.

aromatic nitro compounds, aromatic diamines, aromatic diazonium salts, diazo coupling reactions.

PHYSICAL CHEMISTRY

UNIT II: Electrochemistry [13 M – 1 question out of 2 (of marks 13) is to be answered]

Conductance and measurement of conductance, cell constant, specific conductance and molar conductance. Variation of specific and equivalent conductance with dilution for strong and weak electrolytes. Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility. Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes. Ostwald's dilution law. Debye-Huckel model (physical idea only). Application of conductance measurement (determination of solubility product and ionic product of water). Conductometric titrations. Principles of Moving-boundary method,

Types of electrochemical cells and examples , cell reactions, emf and change in free energy, H and S of cell reactions from emf measurements. Thermodynamic derivation of Nernst equation. Standard cells. Half-cells / electrodes, different types of electrodes (with examples). Standard electrode potential (IUPAC convention) and principles of its determination.

Types of concentration cells. Liquid junction potential and its minimisation. Glass electrode and determination of pH of a solution. Potentiometric titrations: acid-base and redox.

UNIT III: Quantum Chemistry – II [12 M – 1 question out of 2 (of marks 12) is to be answered]

Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic features.

Stationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular parts. Solution of angular-part and emergence of quantum number 'm'; energy expression (without derivation), degeneracy. Hydrogenic wave functions up to n = 2 (expression only); radial distribution functions, real wave function. Concept of orbitals and shapes of s and p orbitals.

Group B *[35 MARKS]*

ORGANIC CHEMISTRY

Unit I. Organometallics and Retro synthesis-I [10 M – 1 question out of 2 (of marks 10) is to be answered]

A. Organometallics:
preparation of Grignard reagent and organolithium.

Reactions: addition of Grignard and organolithium to carbonyl compounds, abnormal reactions, substitution on -COX, conjugate addition by Gilman cuprates (R_2CuLi), Reformatsky reaction, Corey-House synthesis, Wittig reactions.

B. Retrosynthesis-I:
disconnections, synthons, donor and acceptor synthons, functional group interconversion, one group disconnection-synthesis of alcohols, ethers, aldehydes, ketones, acids, acid derivatives, phenols and quinones from retrosynthetic approach.

INORGANIC CHEMISTRY

Chemical Periodicity
General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation and catalytic properties (if any), oxidation states, inert pair effect (if any), aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such hydrides, halides, oxides, oxyacids (if any).

Unit-II:[9] 1 question out of 2 is to be answered
B-Al-Ga-In-Tl, N-P-As-Sb-Bi, and study of the following Compounds/Species: B2H6, borates, borazole, boron nitride, polyphosphates, hydrazine, hydroxylamine, N_3^-, phosphazines and environmental effects of NOx.

Unit-III:[8]1 question out of 2 is to be answered
C-Si-Ge-Sn-Pb, O-S-Se-Te, and study of the following Compounds/Species: (SN)x with x = 2, 4; silicates, silanes, silicones, thionic acids) thio- and per-sulphates, chemical and photochemical reactions of ozone.

Unit IV: [8] 1 question out of 2 is to be answered

F-Cl-Br-I, He-Ne-Ar-Kr-Xe, and study of the following Cmpounds/Species: interhalogens, polyhalides, pseudo halogens, fluorocarbons, freons, Oxides, fluorides and oxofluorides of xenon; Perxenic acid and its salt.

CEMAP4p [25 MARKS]
Revision vide Dated 25.07.2015

Practical (25 M)

Experiments based on Physical Chemistry – I [25M]

1. Determination of solubility of sparingly soluble salts in water and various Electrolyte medium by titrimetric method. KHTa as sparingly soluble salt in water, KCl, $NaNO_3$ may be used.

2. Determination of pH of an unknown solution by colour matching method.

3. Determination of the rate constant for the first order acid catalyzed hydrolysis of an ester (V_0 and $V\propto$ be supplied).

4. Determination of rate constant of decomposition of H_2O_2 by acidified KI solution using clock reactions.

5. Conductometric titration of HCl-AcOH mixture; dibasic acid.

6. Determination of equilibrium constant for $KI + I_2 = KI_3$, using partition coefficient method.

7. Determination of Solubility of a sparingly soluble salt, conductometrically.

SEMESTER 5

CEMAP5t [50 MARKS]

Course outcome:

- **Understanding of crystal lattice and the basic principle of X-ray diffraction**
- **Electrical properties like dipole moment and polarizability of the molecules**
- **Explanation of surface and interfacial phenomenon and general idea about colloidal particles and self-associating systems**
- **The effect of solute on thermodynamic properties of a solution**
- **Understanding of phase diagram of matter and the role of thermodynamic parameters on the equilibrium between phases**
- **Description of the relationship between microscopic and bulk properties of matter**

- **Concept of partition function and its relationship to different thermodynamic properties**
- **Concept of statistical thermodynamics in calculating chemically significant quantities like residual entropy and heat capacities**
- **Attainment of zero Kelvin and adiabatic demagnetisation**
-

PHYSICAL CHEMISTRY

UNIT I: Properties of solids and dielectrics [10 M – 1 question out of 2 (of marks 10) is to be answered]

Crystal, crystal planes, law of rational indices, Calculation of fraction occupied for simple cubic, bcc, and fcc. Miller indices. Bragg's law and its applications for the determination of crystal structure for cubic system single crystal. Crystal structures of NaCl and KCl.

Electrical properties of molecules: Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules. Clausius-Mosotti equation and Debye equation (both without derivation) and their application. Determination of dipole moments.

UNIT II: Surface properties and Colloids [10 M – 1 question out of 2 (of marks 10) is to be answered]

Surface tension, surface energy, excess pressure, capillary rise and surface tension. Work of cohesion and adhesion, spreading of liquid over other surface. Vapour pressure over curved surface. Temperature dependence of surface tension.

Physical and chemical adsorption. Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required). Gibbs adsorption isotherm and surface excess. Heterogenous catalysis (single reactant). Zero order and fractional order reactions. Micelles.

Colloids: Coagulation and Schultz-Hardy rule. Zeta potential and Stern double layer (qualitative idea). Tyndall effect. Electrokinetic phenomenon (qualitative idea only).

UNIT III: Thermodynamics of open systems [10 M – 1 question out of 2 (of marks 10) is to be answered]

Gibbs-Duhem equation; fugacity of gases and fugacity coefficient.

Solubility equilibrium and influence of common ions and indifferent ions thereon. Activity and activity coefficients of electrolyte / ion in solution. Debye-Huckel limiting law (statement and applications only).

Variation of thermodynamic functions for open systems, Euations of states for these systems, Change in G, S H and V during mixing for binary solutions.

Vapour pressure of solution. Ideal solutions, ideally diluted solutions and colligative properties. Raoult's law. Thermodynamic derivation of colligative properties of solution (using chemical potentials) and their inter-relationships. Abnormal colligative properties.

UNIT IV: Phase equilibrium [10 M – 1 question out of 2 (of marks 10) is to be answered]

Definitions of phase, component and degrees of freedom. Phase rule and its derivations. Definition of phase diagram. Phase equilibria for one component system – water, CO_2. First order phase transition and Clapeyron equation; Clausius-Clapeyron equation - derivation and use.

Liquid vapour equilibrium for two component systems. Ideal solution at fixed temperature and pressure. Principle of fractional distillation. Duhem-Margules equation. Henry's law. Konowaloff's rule. Positive and negative deviations from ideal behaviour. Azeotropic solution. Liquid-liquid phase diagram using phenol- water system. Solid-liquid phase diagram. Eutectic mixture.

UNIT V: Statistical thermodynamics and the third law [10 M – 1 question out of 2 (of marks 10) is to be answered]

Macrostates and microstates, Partition function, concept of ensemble - canonical ensemble and grand canonical ensembles, Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation). Applications to barometric distribution.

Einstein's theory of heat capacity of solids. Limitations of Einstein's theory and Debye's modification (qualitative).

Nernst heat theorem. Approach to zero kelvin, adiabatic demagnetisation. Planck's formulation of third law and absolute entropies.

CEMAP6t [50 MARKS]
Revision vide Dated 25.07.2015

Course outcome:

- **Methodologies for synthesis of chiral and heterocyclic molecules**
- **Synthesis and use of common drugs**
- **Synthesis of amino acids and peptides, including Merrifield synthesis**
- **Structure elucidation by modern spectroscopy**
- **Separation by chromatography**
- **Laboratory synthesis of organic molecules**

ORGANIC CHEMISTRY

Unit I: Cyclic stereochemistry and Asymmetric synthesis: [12 M-1 question out of 2 (of marks 12) is to be answered]

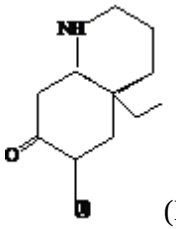
A. Cyclic Stereochemistry:
Baeyer strain theory. Conformational analysis: cyclohexane, mono and disubstituted cyclohexane, symmetry properties and optical activity. Conformation & reactivity in cyclohexane system: elimination (E2),

rearrangement, nucleophilic substitution (S_N1, S_N2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

B. **Asymmetric synthesis**: stereoselective and stereospecific reactions, diastereoselectivity and enantioselectivity, diastereoselectivity: addition of nucleophiles to C=O, adjacent to a stereogenic centre (Cram's rule,Felkin-Anh model), Prelog's rule.

Unit II: Organic Synthesis : [13 M – 1 question out of 2 (of marks 13) is to be answered]

A. **Retrosynthesis-II**: Disconnection approach towards systhesis of bi-functional molecules – cyclic and acyclic systems, C-C disconnections and synthesis of 1,2-, 1,3-, 1,4-, 1,5-, and 1,6-dioxygenated compounds, Thermodynamic factor, synthesis through enolate anion chemistry and carbonyl condensation reactions (using EAA, DEM, ethyl cyanoacetate) , Robinson ring annulations, illogical electrophiles and nucleophiles, some 'real life' examples (molecules having potential drug activity or intermediate products leading to biologically active molecules with special reference to alkaloids). Caffeine, Vivaline, Nicotine, Guanine, Cytosine, An Intermediate (I) in stork's synthesis of Aspidosperma alkaloid (below)



(I)

B. **Synthesis of Amino acids and synthesis using protection and deprotection strategy (alcohol, amine, carbonyl, acid):**
(i) Amino acids: Strecker, Gabriel, acetamidomalonic ester, azlactone, using diketo piperazine; isoelectric point, ninhydrin reaction.

(ii) Protection and deprotection: Alcohol, amine, carbonyl, and acid; use in organic synthesis. Syntheses of peptides using N-protection & C-protection, solid phase peptide synthesis (Merrifield).

Unit III Spectroscopy UV, IR, NMR (elementary): [12 M-1 question out of 2 of marks 12 is to be answered]

UV Spectra*:* Electronic transition (σ-σ^*, n-σ^*, π-π^* and n-π^*), relative positions of λ_{max} considering conjugative effect, steric effect, solvent effect, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples), calculation of λ_{max} using Woodward-Hofmann's rule.

IR Spectra: Modes of molecular vibrations, application of Hooke's law, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C≡C, C=N, C≡N, C=O functions; factors effecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size).
PMR Spectra: Nuclear spin, NMR active nuclei, principle of proton magnetic resonance, relaxation, equivalent and non-equivalent protons, chemical shift δ), shielding / deshielding of protons, up-field and down-field shifts. NMR peak area (integration), diamagnetic anisotropy, relative peak positions of different kinds of protons (alkyl halides, olefins, alkynes, aldehyde H), substituted benzenes (toluene, anisole, nitrobenzene, halobenzenes, dinitrobenzenes, chloronitrobenzenes), first order coupling (splitting of the signals: ordinary ethanol, bromoethane, dibromoethanes), coupling constants.

Unit IV: Polynuclear hydrocarbons and Heterocyclic chemistry: [13 M-1 question out of 2 of marks 13 is to be answered]

A. Polynuclear hydrocarbons:
Synthesis and reactions of naphthalene, anthracene, and phenanthrene.

B. Heterocyclic Chemistry:
Heterocyclic compounds: reactivity, orientation and important reactions of furan, pyrrole, thiophene, pyridine, indole; synthesis (including retrosynthetic approach), pyrrole: Knorr pyrrole synthesis and Hantzsch synthesis. Hantzsch pyridine synthesis.

Indole: Fischer, Madelung and Reissert synthesis, Skraup quinoline and Bischler-Napieralski Synthesis of isoquinoline.

Synthesis, uses, and action of Drugs: Nifedipine, Amlodipine, Ranitidine, Chloroquine.

CEMAP7t [50 MARKS]

Course outcome:

- **Concept of crystal field stabilization energy and Orgel diagram**
- **Concept of Homogeneous and heterogeneous catalysis by organometallic compounds**
- **Concept of EAN and 18-electron rule**
- **Chemistry of some typical Bio-molecules related to life processes**

INORGANIC CHEMISTRY

Unit I. [9 M] 1 question out of 2 is to be answered.
Structure and bonding: VB description and its limitations. Elementary Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; pairing energy. Jahn-Teller distortion. Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

Unit II. [8 M] 1 question out of 2 is to be answered.

Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$-$3d^9$ ions and their spectroscopic ground states; selection rules for electronic spectral transitions; Spectrochemical series of ligands; charge transfer spectra (elementary idea).

Unit III. [8 M] 1 question out of 2 is to be answered.

Elements of life: essential major, trace and ultratrace elements. Storage and transport of energy in biological system, ATP-ADP interconversion, Creatine-Phosphocreatine interconversion, its biological impotance. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}).Metal ion transport across biological membrane, active and passive transport of ions, Na^+-K^+ Transporting ATP-ase: Na+-ion pump.

Unit IV. [8 M] 1 question out of 2 is to be answered.
Active site structure of hemoglobin and myoglobin and their Biological functions, Cytochromes (active site structure of cytochrome-C only), Iron-sulphur proteins: Rubredoxin Ferredoxins. Carbonate bicarbonate buffering system and carbonicanhydrase. Biological nitrogen fixation and nitrogenase enzyme. Photosynthesis: Photosystem-I and Photosystem-II. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases.

Unit V. [9 M] 1 question out of 2 is to be answered.
18-electron rule and its applications to carbonyls (including carbonyl hydrides and carbonylates), nitrosyls, cyanides, and nature of bonding involved therein. Metal-olefin complexes: zeises salt (preparation, structure and bonding), Ferrocene (preparation, structure and reactions). Hapticity (η) of organometallic ligands, examples of mono tri and penta-haptocyclopentadienyl complexes.

Unit VI. [8M] 1 question out of 2 is to be answered.
(a) Metal-Metal multiple bonding and Metal-Clusters, Carbonyl Clusters Nb – Ta Clusters, Mo - Ta Clusters, [L.N.C.C. and H.N.C.C.]; Applications of metal cluster:
(b) Simple examples of fluxional molecules. Coordinative unsaturation: oxidative addition, reductive elimination and insertion reactions. Homogeneous catalysis by organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler-Natta catalysis).synthesis of acetic acid by Monsanto Process.

CEMAP8p [65 MARKS]

Course Outcome

- **Determination of kinetic parameter of chemical reaction employing sophisticated instrument**
- **Determination of important thermodynamic parameters using potentiometer**
- **Experimental elucidation of properties of liquids such as viscosity and surface tension**
- **Laboratory synthesis of organic molecules**

Practical (65 M)

Group A. Experiments based on Physical Chemistry – II [40 M]

1. To study the kinetics of inversion of sucrose using polarimeter.

2. Determination of Surface tension of an unknown liquid by relative method.

3. Determination of Viscosity of an unknown liquid by relative method.

4. Determination of pK values of weak monobasic, dibasic and polybasic acid by pHmetric method (e.g. HCl+acetic acid, oxalic acid, phosphoric acid, etc.).

5. Determination of ionization constant of a weak acid by conductometric method.

6. To study the kinetics of saponification of ester by conductometric method.

7. Determination of E_0 of Fe^{+3}/Fe^{+2} couple in the hydrogen scale by potentiometric titration of ferrous ammonium sulfate solution using $KMnO_4$, or, $K_2Cr_2O_7$ as standard.

8. Determination of concentration of (i) $AgNO_3$ solution and (ii) solubility product of AgCl by potentiometic titration of standard KCl solution against $AgNO_3$ solution.

Group B. Experiment - Organic Preparations [25 M]

A. The following reactions (*at least three*) are to be performed in 2/3-steps organic synthesis, noting the yield of the crude product in each step.
1. Nitration of aromatic compounds
2. Condesation reactions
3. Hydrolysis of amides/ imides/ esters
4. Acetylation of phenols / aromatic amines
5. Benzoylation of phenols / aromatic amines
6. Side chain oxidation of aromatic compounds
7. Oxidation / reduction reaction

B. Purification of the crude product is to be made by crystallisation (water/alcohol, crystallisation after charcoal treatment, or sublimation, whichever is applicable).

C. MP of the purified product is to be noted.

SEMESTER 6

CEMAP9t [50 MARKS]

Course outcome:

- **Concepts of photochemical and photophysical processes with theoretical models and correlation with experimental methods to investigate photochemical reactions**
- **Understanding molecular spectra - including rotational, vibrational and electronic spectra and recognizing relationship between molecular properties and molecular spectra**
- **Study of Bio-molecules**
- **Advance level separation technique**
- **Study of natural products**
- **Pericyclic reactions**

Group A ***[25 MARKS]***

PHYSICAL CHEMISTRY

UNIT I: Molecular Spectroscopy – I [12 M – 1 question out of 2 (of marks 12) is to be answered]

Light-matter interaction (perturbative approach of transition between two states), transition moment integral, selection rule, Spectroscopic arrangements

Rotational spectroscopy of diatomic molecules: rigid rotor model, selection rules, spectrum, characteristic features of spectral lines (spacing and intensity). Determination of bond length, effect of isotopic substitution.

Vibrational spectroscopy of diatomic molecules: SHO model, selection rules, spectra; anharmonicity and its consequences on energy levels, overtones, hot bands. Raman Effect. Characteristic features and conditions of Raman activity with suitable illustrations. Rotational and vibrational Raman spectra. Rule of mutual exclusion with examples.

UNIT II: Molecular Spectroscopy – II [13 M – 1 question out of 2 (of marks 13) is to be answered]

Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra. Bond dissociation and principle of determination of dissociation energy (ground state). Decay of excited states by radiative and non-radiative paths. Fluorescence and phosphorescence, Jablonskii diagram.

Stark-Einstein law of photochemical equivalence and Lambert-Beer's law; quantum yield and its measurement for a photochemical process, actinometry. Photostationary state. Photosensitized reactions. Kinetics of HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene.

Group B ***[25 MARKS]***

ORGANIC CHEMISTRY

Unit I: Natural products and Biomolecules: [15M-1 question out of 2 (of mark 15) is to be answered]

A. Carbohydrates: Monosaccharides (Aldoses upto 6 carbons): Classification of monosaccharides, osazone formation, stepping–up (Kiliani method) and stepping–down (Ruff's & Wohl's method)of aldoses, interconversion between aldose and ketose, epimerization, reaction with acetone and bromine-water, formation of glycosides, ring-size determination – HIO_4 method, structure of D-glucose & D-fructose (configuration & conformation - ring structure), anomeric effect, mutarotation.

Disaccharides: glycosidic linkages, structure of sucrose.

B. Proteins: Peptide linkage, peptide sequence: C–terminal and N–terminal unit determination (Edmann, Sanger & dansyl chloride). Primary and secondary structure of proteins.

C. Nucleic acids: Pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, complimentary base –pairing in DNA.

D. **Terpenoids**: Introduction, classification, isoprene rule, isolation, structure elucidation and synthesis of citral, geraniol, citronellal.

Unit II: Pericyclic reactions -II and Organosilicon chemistry: [10M-1 question out of 2 (of marks 10) is to be answered]

A. **Pericyclic Reactions-II**: Electrocyclic reactions, FMO approach, examples of electrocyclic reactions, (thermal and photochemical) involving 4 and 6 electrons and corresponding cycloreversion reactions. Sigmatropic shifts and their order, [1,3], [1,5] H- & C-shifts and [3,3] shifts with reference to Cope and Claisen rearrangements.

B. Organosilicon chemistry: Use of Me_3SiCl in ester hydrolysis (neutral medium), acyloin condensation (small and medium sized ring synthesis), synthesis of alkene - Peterson reaction, arylsilane, alkenylsilane, allylsilane, silyl enol ether, use of trimethylsilyl cyanide (Me_3SiCN).

Unit III: Special Topics (Not for evaluation**):** (i) Mass Spectroscopy, (ii) Green chemistry.

CEMAP10t [50 MARKS]

Course outcome:

- **Concept of complexometric, permanganometric, argentometric titrations**
- **Concept of co-precipitation and post precipitation**
- **Concept of Errors in chemical analysis**
- **Analysis of water, soil and air sample**
- **Concept of magnetic and spectral properties of Lanthanides and Actinides elements**
- **Basic idea of nano technology**
- **Concept of supramolecular chemistry and explosive chemistry**

Group A ***[25 MARKS]***

ANALYTICAL CHEMISTRY

Unit-I [8 M] 1 question out of 2 is to be answered

Primary and secondary standard substances in acid base, redox, complexometric and argentometric titration. Principles and applications of redox titrimatric estimation based on the use of the following reagents : (i) $KMnO_4$, (ii) $K_2Cr_2O_7$, (iii) I_2, (iv) $Na_2S_2O_3$, $5H_2O$, (v) $KH(IO_3)_2$ and $KBrO_3$

Principle of argentometric estimation of Cl^-, using adsorption indicators.

Principle of EDTA (complexo metric titration), metal ion indicators, masking and demasking reagents and reactions. Estimation of Cu-Zn, Fe-Al, Ca-Mg mix, by EDTA titration methods. Role of Buffer in complexo metric analysis.

Unit-II [8 M]1 question out of 2 is to be answered

Gravimetric analysis: Requirements of gravimetric analysis.
Gravimetric factor : Digestion
Properties of precipitates and precipitating reagents, Re-precipitation, Co- precipitation, Post precipitation, simultaneous precipitation peptisation and coagulation.

Principles of gravimetric estimation of Cl^-, $PO_4^{\equiv}$, Zn^{+2}, Fe^{3+}, Al^{3+}, Mg^{+2}, Ni^{+2} individually.
Dissolution and principles of estimation of dolomite, pyrolusite, chalcopyrites, portland cement, Basic slag, brass, steel

UNIT - III : [9 M] 1 question out of 2 is to be answered

Errors in chemical analysis – Accuracy and Precision of measurements Absolute error, Relative error, Constant error, Random errors, Minimisation of errors, Statistical analysis of errors, Standard deviation and Average

deviation Relative standard deviation

Analysis of water and air sample and soil sample: Detection and estimation of As, Hg, Cd, Pb, in water sample Detection, collection and principles of estimation of CO, $NO_{x,}$ and SPM in air samples.

Ion exchange Resin – principles and applications of ion exchange separation.

Chromatographic method of analysis, separations and classifications - thin layer chromatography, paper and column chromatographic techniques and their applications – R_f values and their significances.

Analysis of water sample: Principles for determination of BOD, COD, DO, TDS in water samples

Group B ***[25 MARKS]***

INORGANIC CHEMISTRY

UNIT I: [9 M] 1 question out of 2 is to be answered.

Chemistry of d- block elements: General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties. Group Comparative study of (a) Ti, Zr, Hf (b) Cr, Mo, W (c) Fe, Co, Ni.

Chemistry of f- block elements: Electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of 4f and 5f block elements, lanthanide contraction, consequences and effects comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method). Application of lanthanides and actinides.

UNIT II: [(8 M] 1 question out of 2 is to be answered

a) Isomerism of inorganic complexes, Geometrical, optical and other various types of isomerism of coordination compounds. Determination of cis-trans isomers by chemical method.

b) Stability constants of coordination compounds and factors affecting stability of complexes; Their importance in inorganic chemistry (Co-ordination compounds); Stepwise stability constants and overall stability constants and their relationships; Irving-William order of stability, basic principles UV-visible spectro-photometry,determination of stability constants, Jobs Method, Mole-ratio Method.

UNIT III: [(8 M] 1 question out of 2 is to be answered

Redox reactions in complexes, complementary and non-complementary redox rection, outer sphere and inner sphere mechanism in redox reactions. Labile and inert complexes. Macrocyclic effect.Trans effect, Trans influence, Cis effect, Substitution reactions in square planar, tetrahedral and octahedral complexes.

Basic ideas of Nano-Chemistry

a) General Definition, nano effects,
b) Synthesis of nano particles
c) Applications

Special lecture:(Not to be evaluated)

A. Supra molecular Chemistry:

1) Distinguish between Super molecules and Supra molecules
2) **Nature of Supra molecular interactions** – Effect of ligand, Effect of metal ions, Effect of Counter ions and effect of solvents.
3) Applications:
   (i) molecular recognition,

(ii) molecular reecptors
(iii) Molecular Sensors
(iv) Molecular Switches
(v) solubilisation of alkali metals anion alkalides
(vi) invers crown ethers

B. Chemistry of Explosives:
Classification, Nature of reaction, overoxidised and underoxidised explosives, suitable combination of explosives, detonation velocity, redox activity in relation to explosive actions.

CEMAP11p [85 MARKS]

Course outcome

- **Estimation of complex bio molecules such as amino acids and vitamin**
- **Experimental analysis of ore and alloy**
- **Experimental analysis of synthesized organic molecules by modern spectroscopy**
- **Separation of organic molecules from a mixture employing column and thin layer chromatography**
- **Application of Spectrophotometry to study reaction kinetics**
- **Experimental elucidation of thermodynamics of liquid mixtures**
- **Estimation of individual metal ions and metal ions in mixture spectrophotometrically and titrimetrically**
-

Practical (85 M)

Group A. Experiments based on Analytical Chemistry – II [20 M]

Any Six Experiments

1. Total manganese in a pyrolusite
2. Iron in cement
3. Alloy Analysis– Copper in Brass
4. Ore Analysis— Calcium and Magnesium in Dolomite

5. Hardness of water complexometrically [Analysis of water-$As^{3+,}$ F^{-}spectrophotometrycally (**Not for evaluation)]**
6. Estimation of Aniline
7. Estimation of Vit. C
8. Estimation of Glycin
9. Gravimetric Analysis— Estimation of Cl^{-}, Ni^{2+}, SO_4^{2-}
10. Estimation of phosphate in cold drinks
11. **Column chromatography**

<u>Group B. Experiments based on Inorganic Chemistry – II [30 M]</u>

A. Preparation of Primary standard solutions ($K_2Cr_2O_7$, Oxalic Acid)
Preparation of Secondary Standard solutions ($KMnO_4$, $Na_2S_2O_3.5H_2O$, Mohr Salt soln.)
   1. Standardization of Mohr Salt and estimation of Iron (Fe^{2+})
   2. Standardization of Sodium thiosulphate and estimation of copper (Cu^{2+})
   3. Standardization of $KMnO_4$ and estimation of calcium (Ca^{2+})

B. Mixture separation:
   1. Estimation of Fe^{3+} and Cu^{2+} in a mixture iodometrically
   2. Estimation of Fe^{3+} and $Cr_2O_7^{2-}$ in a mixture dichrometrically

C. Complexometric estimation using EDTA as secondary standard and zinc acetate as primary standard
Calcium and Magnesium in a mixture.

<u>Spectrophotometric estimation of:</u> Fe^{2+}, Cr^{6+}, Mn^{7+} (**<u>any two</u>**)

<u>Group C. Experiments based on Organic Chemistry [15 M]</u>

A. UV, IR, NMR analysis of the products prepared in semester V/VI

B. Thin layer chromatography: Separation of amino-acids, TLC monitoring.

<u>Group D. Experiments based on Physical Chemistry [20 M]</u>

1. Study of the kinetics of the reaction $I_2 + S_2O_8$ - by colorimetric method.

2. Determination of pKIn of an indicator by spectrophotometric method.

3. To study the Lambert-Beer's law

4. To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl).

5. Determination of CMC from micellization (conductometric)

BOOKS RECOMMENDED

A. Physical Chemistry (authors)

1. Atkins & de Paula
2. Castellan
3. Levine
4. McQuarrie & Simons

5. Engel & Reid
6. Alberty & Silbey
7. P C Rakshit
8. K.L. Kapoor (Vol I to V)
9. Maron & Prutton
10. Glasstone

B. Organic Chemistry

1. Stereochemistry of organic compounds - D. Nasipuri
2. Advanced organic chemistry – Jerry March
3. Basic Stereochemistry of organic molecules – Subrata Sengupta
4. A Guide to Mechanism in Organic Chemistry – P.Sykes
5. Organic Chemistry (Vol. I & II) - I. L.Finar
6. Organic Synthesis: The disconnection approach – S.Warren
7. Organic Chemistry – Clayden & others
8. Organic Spectroscopy- pavia
9. Pericyclic chemistry- Dipak K. Mandal
10. Pericyclic Reactios - Ian Fleming
11. Prof. G. N. Mukherjee; University Hand book of Undergraduate chemistry experiments.

B. Inorganic Chemistry

1. Inorganic Chemistry- D.F.Shriver, P.W. Atkins and C.H. Langford.
2. Coordination Chemistry-S. F. A. Kettle.
3. Basic Inorganic Chemistry –F.A. Cotton, Wilkinson & P. Gaus.
4. New Concise Inorganic Chemistry- J. D. Lee.
5. Modern Inorganic Chemistry- W. L. Jolly.
6. Organometallic Chemistry – R. C. Mehorotra & Singh.
7. Elementals of Bioinorganic Chemistry- G.N. Mukherjee & A. Das.
8. General and Inorganic Chemistry – volume I and II- R. P. Sarkar.
9. Inorganic Chemistry – volume I and II- R. L.Dutta.
10. General and Inorganic Chemistry – volume I, II, III, IV, V, VI, VII and Nano Chemistry: A. K. Das

11. Selected Topics in Inorganic Chemistry- W. U. Malik. G. D.Tulli and R.D.Madan.
12. Advanced Inorganic Chemistry- F.A.Cotton and G. Wilkinson.
13. Inorganic Chemistry- J.E. Huheey, E.A. Keiter & R.L. Keiter.
14. Chemistry of the elements- N.N. Greenwood & A. Earnshaw.
15. An Introduction to Inorganic Chemistry- K.L. Purcel & J.C. Kotz.
16. Essentials of Nuclear Chemistry- H.J. Arnikar.
17. Analytical Chemistry- G.D. Christian.
18. Valence- C.A. Coulson.
19. Fundamentals of analytical chemistry (Skoog, Douglas A.; West, Donald M.)
20. Electroanalytical Chemistry- A.J. Bard.

Inorganic Practical

1. Macro and Semimicro qualitative Analysis- A.I. Vogel.
2. Spot tests in Inorganic Analysis- F. Feigel & V. Anger. (Translated by R. Oesper)
3. Quantitative Inorganic Analysis- A. I. Vogel.
4. An Advanced Course in Practical Chemistry: Ghoshal, Mhapatra, Nad
5. Advanced Experiments in Inorganic Chemistry: Mukherjee G. N.
6. A Hand Book of Practical Chemistry: K.R. Mahadik and S.H. Bhosal.

REFERENCE BOOKS

A. Physical Chemistry (authors)

1. Mortimer
2. Berry, Rice & Ross
3. Glasstone & Lewis
4. Dittman & Zemansky
5. Laidler
6. Banwell
7. Barrow
8. Hollas
9. Levine
10. Atkins
11. Denbigh

12. Nash
13. Dogra & Dogra
14. Adamson
15. Glasstone
16. Feynman (Vol I to III)
17. Kreyszig

B. Organic Chemistry

1. Advanced Organic Chemistry (Vol. I & II) – Carey & Sundberg
2. Organic Synthesis – House
3. Principle of Organic Synthesis - R.O.C. Norman and J.M.Coxon
4. Modern methods of Organic Synthesis – Carruthers and Coldhan
5. Spectroscopy – Kemp
6. Spectroscopy – Silverstein
7. Organic Chemistry – G.M.Loudon
8. Organic Chemistry – Solomons
9. Spectroscopic methods in Organic chemistry- D.Williams and Ian Fleming
10. H. T. Clarke - A Hand book of organic analysis
11. Subhas C Das - Advanced practical Chemistry
12. Furniss, Hannaford, Smith, Tatchell - Vogel's text book of practical Chemistry
13. Ghoshal, Mahapatra, Nad - An Advance course in practical Chemistry

B.Sc. Chemistry Generic Elective

Course Structure

Sl No	Name of the Course	Semester	Course Code	Credit	Marks in the Course	Course outcome
16	General Chemistry , Physical Chemistry	1	CEMG-P1-T	2	50	Concept on quantum numbers, Concept of Stability of nucleus and nuclear energy, Concept of electro negativity, electron affinity and ionisation energy, Speed of a chemical reaction may be defined, measured and can be related to concentration of the reaction components and temperature, Function of catalyst (specially the homogeneous ones and enzymes), Study of conductance, specific conductance and equivalent conductance for electrolytic solutions, van-der-Waals gas equation in real gases, Surface tension and viscosity of liquid state, First law of thermodynamics (heat, work, internal energy change, enthalpy) and its application in different types of process, Detection of functional group present in organic molecules.
17	Organic Qualitative Analysis	1	CEMG-P1-P	1	25	
18	Inorganic Chemistry, Organic Chemistry	2	CEMG-P2-T	2	50	Concept of hybridization and shape of molecules/ions, Concept of Molecular orbital and bonding, Concept of lattice energy and its application, Concept of various acid-base theory, Concept of redox and formal potential, feasibility of reaction, Study of reaction intermediates and reaction mechanism, Stereochemistry of organic compounds, Chemistry of carbonyl compounds, Concept on quantitative and qualitative
19	Quantitative Analysis of inorganic sample(s) Qualitative Analysis of	2	CEMG-P2-P	1	25	

	Single Inorganic Compound					sample analysis
20	Inorganic Chemistry	3	CEMG-P3-T	1	25	Concept of oxidation state , hydride, halid of different main group elements, Concept of oxo and peroxo compound, Concept of polymeric compounds, Know the various type of reaction of different elements, Separation and identification of various ions (cations and anions)
21	Systematic Qualitative analysis of unknown mixture of solid inorganic salts	3	CEMG-P3-P	2	50	
22	General Chemistry, Organic Chemistry, Physical Chemistry	4	CEMG-P4-T	3	75	Comparative study on group-IB and group II-B elements, Reaction study of different functional groups and orgmetallic compounds, Study of aromatic compounds and nitrogen congaing molecules, Chemistry of biomolecules, The second law of thermodynamics, entropy and free, Chemical equilibrium, solubility and solubility product, Colligative properties of a solution, azeotropic and eutectic behaviour, Colloids and their characteristic

CHEMISTRY GENERAL

2017-2020

SEMESTER-I (Paper I)

Course outcome:

- **Concept on quantum numbers, Concept of Stability of nucleus and nuclear energy, Concept of electro negativity, electron affinity and ionisation energy, Speed of a chemical reaction may be defined, measured and can be related to concentration of the reaction components and temperature, Function of catalyst (specially the homogeneous ones and enzymes), Study of conductance, specific conductance and equivalent conductance for electrolytic solutions, van-der-Waals gas equation in real gases, Surface tension and viscosity of liquid state, First law of thermodynamics (heat, work, internal energy change, enthalpy) and its application in different types of process, Detection of functional group present in organic molecules.**

CEMGP01T (50M)
[Credit: 2]

Group A (General Chemistry)[25M]

Unit I-(13 M)

(a) Radioactivity- Units, n/p ratio and stability- nuclear binding energy- nuclear reactions (Fission, Fusion).

(b) Extranuclear structure of atom- Bohr's theory of hydrogen atom. Pauli Exclusion Principle. Hund's rule. Aufbau Principle. Different quantum numbers and their significances.

(c) Chemical periodicity- Periodic properties of s, p, d, f block elements. Periodic table in terms of electronic configuration,diagonal relationship with example. Position of hydrogen and noble gases in periodic table.
I.U.P.A.C nomenclature of elements (atomic number above 100)
Atomic radii, Ionic radii, Electron affinity electronegativity in Pauling scale. Periodic and group wise variation of above properties in respect of s and p block elements only.

Unit II- (12 M)

a) Kinetics : Order and molecularity of chemical reactions, rate constant, zeroth, first, second and general n-th order reactions. Temperature dependence of rate constant: Arrhenius equation, energy of activation, Outline of Collision theory. Catalysis: Homogeneous catalysis, Enzyme catalysis: Michaelis-Menten equation

b) Conductance: Definitions of conductance, specific conductance and equivalent conductance, variation of all these quantities with concentrations, Law of independent migration of ions, Ostwald dilution law for weak electrolytes

Group B (Physical Chemistry)[25M]

Unit II- (12 M)

c) Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature, Maxwell's distribution law of molecular speeds without derivation), most probable, average and root mean square speed of gas molecules, principle of equipartition of energy (without derivation). Mean free path and collision frequencies. Heat capacity of gases (molecular basis); viscosity of gases.

Real gases, compressibility factor, deviation from ideality, van der Waals equation of state, critical phenomena, continuity of states, critical constants.

d) Liquid state: physical properties of liquids and their measurements: surface tension and viscosity, Effect of temperature on these properties

Unit II [13 M]

Definition of thermodynamic terms: Intensive and extensive variables, isolated, closed and open systems. Cyclic, reversible and irreversible processes. Thermodynamic functions and their differentials. Zeroth law of thermodynamics, concept of heat (q) and work (w).

First law of thermodynamics, internal energy (U) and enthalpy (H); relation between Cp and Cv, calculation of w, q, ΔU and ΔH for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion. Joule-Thomson Coefficient and inversion temperature.

Thermochemistry: standard state, standard enthalpy changes of various physical and chemical transformations, Hess's law of constant heat summation. Bond-dissociation energy, Kirchhoff's equation, relation between ΔH and ΔU of a reaction.

PRACTICAL

CEMGP01P (25M)
[Credit: 1]

Organic Qualitative Analysis (25M)

Syllabus :

(a) Qualitative Analysis of Single Organic Compound(s)

- Detection of special elements N, S and Cl in an organic compound (only Lassaigne's test).
- Analysis of samples based on solubilities.
- Detection of the following functional groups: Aromatic primary amino group (Diazo-coupling reaction); Nitro group (Mulliken Barker's test); Carboxylic acid group (reaction with NaHCO3); Phenolic OH (FeCl3 test); Carbonyl (aldehyde and ketone) group (DNP Test, etc.).
- Experiments 1 - 2 with unknown (at least 5) solid samples containing not more than two of the above types of functional groups should be done.

SEMESTER-II (Paper II)

Course outcome:

- **Concept of hybridization and shape of molecules/ions, Concept of Molecular orbital and bonding, Concept of lattice energy and its application, Concept of various acid-base theory, Concept of redox and formal potential, feasibility of reaction, Study of reaction intermediates and reaction mechanism, Stereochemistry of organic compounds, Chemistry of carbonyl compounds, Concept on quantitative and qualitative sample analysis**

CEMGP02T (50M)
[Credit: 2]
Revision vide Dated 25.07.2015

Group A (Inorganic Chemistry)[25M]

Unit I : (13 M)

(a) Ionic bonding: General characteristics of ionic compounds, sizes of ions - Radius ratio rule and its limitation. Lattice energy. Born- Haber cycle.

(b) Covalent bonding: General characteristics of covalent compounds, valence-bond approach, directional character of covalent bond, hybridization involving s, p and d-orbitals, multiple bonding. Hydrogen bonding and its effect. Drawbacks of Valance- Bond theory

(c) Valence Shell Electron Pair Repulsion (VSEPR) concept, Shapes and geometry of the molecules and ions (examples from main group chemistry). Bond moment and dipole moment, partial ionic character of covalent bonds.

(d) Werners theory. I.U.P.A.C nomenclature of Co-ordination compounds, ligands. chelate complexes, examples of complexes with structure of coordination numbers 4 and 6.

Unit II : (12M)

(a) Elementary concept of molecular orbital theory (M.O theory)- Bond order- M.O Diagram of H_2,F_2, O_2, N_2, CO and NO. Qualitative idea of Band theory of metals. Conductors, Semiconductors and insulators (with examples).

(b) Acid- Base concept, pH, buffer Lux Flood concept and Lewis concept of acid and bases.

(c) Redox Chemistry Nernst equation- Elementary idea of standard redox potential, formal potential- Electrode potential, redox indicators, Disproportionation and comproportionation reactions.

Group B (Organic Chemistry)[25M]

Unit I. [15M]

Inductive effect, resonance and resonance energy. Homolytic and heterolytic bond breaking, electrophiles and nucleophiles; carbocations, carbanions and radicals (stability and reactivity)

Stereochemistry of carbon compounds: Different types of isomerism, geometrical and optical isomerism, optical activity, asymmetric carbon atom, elements of symmetry (simple axis of symmetry, Plane of Symmetry, Centre of symmetry and alternative axis of symmetry), chirality, enantiomers and diastereomers, R and S nomenclature, E and Z nomenclature, D and L nomenclature, Fischer projection formula of simple molecules containing one and two asymmetric carbon atoms.

Alkanes, alkenes and alkynes: Synthesis and chemical reactivity of alkanes, mechanism of free-radical halogenation of alkanes, general methods of synthesis of alkenes, electrophilic addition reaction, mechanism of bromination and hydrohalogenation, Markownikoff's addition, peroxide effect, hydroboration, ozonolysis, polymerization reaction of alkenes (definition and examples only).General methods of synthesis, acidity, hydration and substitution reactions of alkynes.

Aromatic Hydrocarbons: Structure of benzene, general mechanism of electrophilic substitution, reactions of benzene, synthesis of aromatic compounds using nitration, halogenation, Friedel-Craft's reactions.

Unit II: [10 M]

Aldehydes and ketones: the nature of carbonyl group, methods of synthesis, physical properties, Cannizzaro reaction, relative reactivities and distinction of aldehydes and ketones, Aldol condensation (with mechanism), Perkin reaction, Benzoin condensation, Claisen condensation, Oxidation and reduction reactions.

Alkyl and Aryl halides: SN1, SN2, E1 and E2 reactions (elementary mechanistic aspects), Saytzeff and Hoffmann elimination reactions. Nucleophilic aromatic substitution.

PRACTICAL (25M)

CEMGP02P (25M)
[Credit: 1]

(a) Quantitative Analysis of inorganic sample(s) **[15M**]

- Estimation of Mohr salt,
- Estimation of Fe^{3+} ion
- Estimation of Cu^{+2} ion

(b) Qualitative Analysis of Single Inorganic Compound **[10M]**

Syllabus :

The following tests are to be performed in a systemetic manner for detection of the acid and basic radicals mentioned below

- Experiments A: Preliminary Tests for Acid and Basic radicals (only those that are listed below) in given samples.
- Experiments B: Wet tests for Acid and Basic radicals (only those that are listed below) in given samples.
- Experiments C: Confirmatory tests.

Acid Radicals : F^-, Cl^-, Br^-, I^-, NO_2^{-1}, S^{2-}, $S_2O_3^{2-}$, SO_4^{-2}, PO_4^{-3}, BO_3^{3-}, H_3BO_3.
Basic Radicals : NH_4^+, Na^+, K^+, Ca^{+2}, Sr^{+2}, Ba^{+2}, Cr^{+3}, Al^{3+}, Mn^{+2}, Fe^{+3}, Ni^{+3}, $Co^{2+/3+}$, Zn^{2+}, Cu^{+2}, Cd^{2+},., Pb^{2+},$Sb^{3+}/^{5+}$
Insoluble salts: Al_2O_3, Cr_2O_3, Fe_2O_3, CaF_2, $BaSO_4$

SEMESTER III (Paper III)

Course outcome:

- **Concept of oxidation state , hydride, halid of different main group elements, Concept of oxo and peroxo compound, Concept of polymeric compounds, Know the various type of**

reaction of different elements, Separation and identification of various ions (cations and anions)

CEMGP03T [25M]
[Credit: 1]

(Inorganic Chemistry)[25M]

Unit I- 13 M

Group trends, Electronic configuration, Common oxidation states, Inert pair effect, Comparative studies with respect to physical and chemical properties, and important compounds of that group.
(i) Group 13- B-Al-Ga-In-Tl
(ii) Group 14- C- Si- Ge- Sn- Pb
(iii) Group 15- N- P- As- Sb- Bi.

Unit- II 12 M

Group trends, Electronic configuration, Common oxidation states, Inert pair effect, Comparative studies with respect to physical and chemical properties, and important compounds of that group.
(i) Group 16- O- S- Se- Te
(ii) Group 17- F, CL- Br- I
(iii) Group 18- He- Ne- …. Rn compounds of Xe.

PRACTICAL (50M)

CEMGP03P (50M)
[Credit: 2]

Systematic Qualitative analysis of unknown mixture of solid inorganic salts.
In the practical examination the given unknown salt should contain three radicals from the above list. At least 6 unknown salt samples are to be alalyzed during laboratory session.

SEMESTER 4 (Paper IV)

Course outcome:

- **Comparative study on group-IB and group II-B elements, Reaction study of different functional groups and orgmetallic compounds, Study of aromatic compounds and nitrogen congaing molecules, Chemistry of biomolecules, The second law of thermodynamics, entropy and free, Chemical equilibrium, solubility and solubility product, Colligative properties of a solution, azeotropic and eutectic behaviour, Colloids and their characteristic**

Group A (General Chemistry)[25M]

CEMGP04T (75M)
[Credit: 3]

Unit- I [15 M]

Group trends, Electronic configuration, Common oxidation states, Inert pair effect, Comparative studies with respect to physical and chemical properties, and important compounds of that group.
(i) Group (IB)- Copper, Silver, and Gold
(ii) Group (IIB)- Zinc, cadmium, and mercury

Group B (Organic Chemistry)[30M]

Unit I. [15M]

a) Carboxylic acids and their derivatives: acidity of carboxylic acids and effects of substituents on acidity, chemical reactivity, mechanism of esterification of carboxylic acids and hydrolysis of esters (BAC2 and AAC2 only)

c) Organometallic compounds: Grignard reagents – preparations and reactions, application of Grignard reagents in organic synthesis. [1^0-, 2^0- and 3^0-alcohols, aldehydes, ketones and carboxylic acids.]

d) Organic compounds containing nitrogen: aromatic nitro compounds – reduction under different conditions. [acidic, neutral and alkaline]. Methods of synthesis of aliphatic amines, Heinsberg's method of amine separation, Hofmann degradation, Gabriel's phthalimide synthesis, distinction of primary, secondary and tertiary amines; methods of synthesis of aromatic amines, basicity of aliphatic and aromatic amines.Diazotization and coupling reactions and their mechanisms; synthetic applications of benzene diazonium salts. [Sandmeyer's reaction, preparation of nitro compounds, phenols, carboxylic acids and hydrocarbons thereby]

Unit II [15M]

a) Carbohydrates, Introduction, occurrence and classification of carbohydrates, constitution of Glucose, osazone formation of reaction of Glucose and Fructose, mutarotation, cyclic structures pyranose and furanose forms (determination of ring-size excluded), epimerization chin lengthening (Kiliani – Fisher method) and chainshortening (Ruff's method) in aldoses.

b) Amino acids, Proteins, methods of synthesis of a a-amino acids (glycine and alanine using Gabriel's phthalimide synthesis and Strecker synthesis) physical properties. Zwitterion structures, isoelectric point.
b) Phenols: synthesis, acidic character and chemical reactions of phenols, Kolbe reactions, Reimer-Tiemann reaction, Fries rearrangement, Claisen rearrangement.

Group C (Physical Chemistry)[30M]

Unit I. [15 M]

a) Spontaneous processes, heat engine, Carnot cycle and its efficiency, Second law of thermodynamics, Entropy (S) as a state function, molecular interpretation of entropy, entropy changes in simple transformations. Free energy: Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of a process.

b) Chemical equilibrium: chemical equilibrium of homogeneous and heterogeneous systems, derivation of expression for equilibrium constants; temperature, pressure and concentration dependence of equilibrium constants (K_P, K_C, K_X); Le Chatelier's principle of dynamic equilibrium.

b) Solubility, solubility product, common ion effect, measurement of solubility and solubility product.

Unit II. [15 M]

a) Solutions of non-electrolytes: Colligative properties of solution, Raoult's Law, relative lowering of vapor pressure, osmosis and osmotic pressure; elevation of boiling point and depression of freezing point of solvents (without derivation)

b) Phase, component, degrees of freedom, phase rule (without derivation), phase diagram (H_2O and CO_2 as example), distillation phenomena, azeotropic mixture, eutectic mixture

c) Colloids: colloids and crystalloids, classification of colloids, Properties of colloids: Brownian motion, dialysis, Tyndal effect, gold number, isoelectric points, coagulation of colloids by electrolytes, Schulze-Hardy rule.

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