STAREX UNIVERSITY

SCHOOL OF PHYSICAL SCIENCES

B.Sc. (H) Chemistry

Course Structure & Syllabus Outline

STAREX UNIVERSITY
GURUGRAM, HARYANA- 122413

PREAMBLE

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters. The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students.

Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades. The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

CHOICE BASED CREDIT SYSTEM (CBCS)

A new system, Choice Based Credit System (CBCS) in being introduced based on the recommendation of University Grant Commission (UGC) to create uniformity in teaching at various central universities and to facilitate seamless mobility of students across universities based on the credits. This credit based semester system will provide flexibility in designing curriculum and assigning credits based on the course contents and number of hours of teaching. In this system students have the option to take courses of their choice, learn at their own pace, take additional courses and acquire more than the required credits, making it an interdisciplinary approach of learning. This new syllabus was been prepared keeping in view the unique requirements of B.Sc. (Hons.) Chemistry students. The contents have been drawn to accommodate the widening horizons of the chemistry discipline and reflect the changing needs of the students. The semester wise course distribution and detailed syllabus for each paper is appended with a list of suggested reading.

Under this system, there will be 14 core course paper (C1 to C14). These are compulsory to be studied by a student to complete the requirement of B.Sc. (Hons.) Chemistry.The students will study two core papers per semester in first year, two core paper per semester in the second year and two core papers per semester in the third year. The core papers (6 credits each) will comprise of theory (4 credits) and practical's (2 credits). Each practical batch will be of 15 students. A number exceeding 15 (at least ten) will be divided into equal batches.

Elective courses can be chosen from a pool of papers. There are two kinds of electives:

A) **Discipline Specific Elective (DSE)**: There are nine such papers (DSE: 1-9) out of which chemistry student will choose any two in fifth and sixth semester each. The Discipline specific elective papers (6 credits each) will comprise of theory (4 credits) and practical's (2 credits) like the core papers. A particular option of DSE paper will be offered in V and VI semester, only if the minimum number of students opting for that paper is 10. One of the elective in DSE is project work which can be opted in lieu of one of the elective and will also carry 6 credits. Number of students who will be offered project work will vary from for college depending upon the infrastructural facilities and may vary each year. The college shall announce the number of seats for project work well in advance and may select the students for the same based on merit. Project will involve experimental work and the student will have to do this in the time after their regular theory and practical classes. The final evaluation of the project work will be through a committee involving internal and external examiners. In this regard guidelines provided by Starex University for executing and evaluation of project work will be final. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

B) **Generic Elective (GE)**: Different generic elective papers will be offered to students of other departments of the college and the student will have the option to choose one generic elective paper each in the first four semesters. The generic elective will be of six credits each. The Department of Physics is offering eight generic elective papers (GE: 1-8) for students of other departments. These generic elective papers (6 credits each) will comprise of theory (4 credits) and practical's (2 credits).

Besides the core and elective courses, there are two **ability enhancement compulsory courses**, AE-I (Environmental Sciences) and AE-2 (English Communication) of two credits each. The student is supposed to take one in each semester of the first year. The students will also undertake one skill enhancement course of two credits in semester III which will be compulsory for app the students of B.Sc Chemistry honors and two skill Enhancement (SE) courses of four credits each in IV and V semesters of second year which they can choose from the list of SE courses offered by their college. The Department of chemistry is offering seven such papers (SE: 1-7).

In the CBCS system, a credit is unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week. A minimum of 148 credits are required to obtain degree in B.Sc. (Hons.) Chemistry.

Details of Courses under B.Sc. (H) Chemistry Undergraduate Programme

COURSE	CREDITS	
	Theory + Practical	**Theory + Tutorials**
1. Core Course (14 Papers in three years) **Core Course Practical / Tutorial*** (14 Practical/ Tutorials* in three years)	14X4= 56 14X2=28	14X5=70 14X1=14
2. Elective Course **A.1 Discipline specific electives** (4 Papers) **A.2 Discipline specific electives practical's/ tutorials** (4 Papers in last two semesters) **B.1 Generic electives** (4 Papers in first four semesters) **B.2 Generic electives practical's/ tutorials** (4 Papers)	 4x4=16 4X2=8 4x4=16 4x2=8	 4X5=20 4X1=4 4x5=20 4x1=4
✦ Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester.		
3. Ability Enhancement Courses **a. Ability Enhancement Compulsory** (2 Papers of 2 credits each in fist 2 semesters) **b. Ability Enhancement Elective** (Skill Based) (2 Papers of 2 credits each in first two semesters)	 2 X 2=4 2X 2=4	 2X2=4 2X 2=4
	Total credit= 140	**Total credit= 140**

*wherever there is practical there will be no tutorials and vice –versa.

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B. Sc. Honours (Chemistry)

	CORE COURSE (14)	**Ability Enhancement Compulsory Course (AECC) (2)**	**Ability Enhancement Elective Course (AEEC) (2) (Skill Based)**	**Elective: Discipline Specific DSE (4)**	**Elective: Generic (GE) (4)**
I	Inorganic I: Atomic Structure & Chemical Bonding-I Physical I: States of Matter & Ionic Equilibrium	(English Communication/MIL) /Environmental Science			GE-1
II	Organic I: Basics & Hydrocarbons Physical II: Chemical Thermodynamics & its Applications	Environmental Science/ (English/MIL Communication)			GE-2
III	Inorganic II: s- and p-Block Elements Organic II: Oxygen Containing Functional Groups Physical III: Phase Equilibria & Chemical Kinetics		Basic Analytic Chemistry		GE-3
IV	Inorganic III: Coordination Chemistry Organic III: Heterocyclic Chemistry		Fuel Chemistry& Chemistry of Cosmetics & Perfumes		GE-4

	Physical IV: Electrochemistry				
V	Organic IV: Biomolecules			DSE-1	
	Physical V: Quantum Chemistry & Spectroscopy			DSE -2	
VI	Inorganic IV: Organometallic Chemistry			DSE -3	
	Organic Chemistry V: Spectroscopy			DSE -4	

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course-I	English Communications/ Environmental Science	2
	Core Course-I	Inorganic Chemistry-I	4
	Core Course-I Practical	Inorganic Chemistry-I Lab	2
	Core Course-II	Physical Chemistry-I	4
	Core Course-II Practical	Physical Chemistry-I Lab	2
	Generic Elective -1	GE-1	4/5
	Generic Elective -1 Practical/Tutorial		2/1
II	Ability Enhancement Compulsory Course-II	English Communications/ Environmental Science	2
	Core Course-III	Organic Chemistry-I	4
	Core Course-III Practical/Tutorial	Organic Chemistry-I Lab	2
	Core Course-IV	Physical Chemistry-II	4
	Core Course-IV Practical/Tutorial	Physical Chemistry-II Lab	2
	Generic Elective -2	GE-2	4/5
	Generic Elective -2 Practical/Tutorial		2/1
III	Core Course-V	Inorganic Chemistry-II	4
	Core Course-V Practical/Tutorial	Inorganic Chemistry-II Lab	2
	Core Course-VI	Organic Chemistry-II	4
	Core Course-VI Practical/Tutorial	Organic Chemistry-II Lab	2
	Core Course-VII	Physical Chemistry-III	4
	Core Course-VII Practical/Tutorial	Physical Chemistry-III Lab	2
	Skill Enhancement Course -1	SEC-1	2

	Generic Elective -3	**GE-3**	**4/5**
	Generic Elective -3 Practical/Tutorial		**2/1**
IV	**Core Course-VIII**	**Inorganic Chemistry-III**	**4**
	Course-VIII Practical/Tutorial	**Inorganic Chemistry-III Lab**	**2**
	Core Course-IX	**Organic Chemistry-III**	**4**
	Course-IX Practical/Tutorial	**Organic Chemistry-III Lab**	**2**
	Core Course-X	**Physical Chemistry-IV**	**4**
	Course-X Practical/Tutorial	**Physical Chemistry-IV Lab**	**2**
	Skill Enhancement Course -2	**SEC -2**	**2**
	Generic Elective -4	**GE-4**	**4/5**
	Generic Elective -4 Practical		**2/1**
V	**Core Course-XI**	**Organic Chemistry-IV**	**4**
	Core Course-XI Practical/Tutorial	**Organic Chemistry-IV Lab**	**2**
	Core Course-XII	**Physical Chemistry-V**	**4**
	Core Course-XII Practical/Tutorial	**Physical Chemistry-V Lab**	**2**
	Discipline Specific Elective -1	**DSE-1**	**4**
	Discipline Specific Elective -1 Practical/Tutorial	**DSE-1 Lab**	**2**
	Discipline Specific Elective -2	**DSE-2**	**4**
	Discipline Specific Elective- 2 Practical/Tutorial	**DSE-2 Lab**	**2**
VI	**Core Course-XIII**	**Inorganic Chemistry-IV**	**4**
	Core Course-XIII Practical/Tutorial	**Inorganic Chemistry-IV Lab**	**2**
	Core Course-XIV	**Organic Chemistry-V**	**4**
	Core Course-XIV Practical/Tutorial	**Organic Chemistry-V Lab**	**2**
	Discipline Specific Elective -3	**DSE-3**	**4**
	Discipline Specific Elective -3 Practical/Tutorial	**DSE-3 Lab**	**2**
	Discipline Specific Elective-4	**DSE-4**	**4**
	Discipline Specific Elective -4 Practical/Tutorial	**DSE-4 Lab**	**2**
Total Credits			**140**

Semester I

CORE COURSE- 1

INORGANIC CHEMISTRY-I

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section- A

Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(14 Lectures)**

Section- B

Periodicity of Elements:

s,*p*,*d*,*f* block elements ,the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block:

a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
b) Atomic radii (vanderWaals)
c) Ionic and crystal radii.
d) Covalent radii (octahedral and tetrahedral)
e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
f) Electron gain enthalpy, trends of electron gain enthalpy.

g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization,group electronegativity. Sanderson's electron density ratio. **(16 Lectures)**

Section- C

Chemical Bonding:

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations.Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvationenergy.

Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR),shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. **(16 Lectures)**

Section- D

MetallicBond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. **(14 Lectures)**

Suggested Books:

a) Lee, J.D.ConciseInorganicChemistryELBS,1991.
b) Douglas,B.E.andMcDaniel,D.H.Concepts&ModelsofInorganicChemistryOxford, 1970
c) Atkins,P.W.&Paula,J.PhysicalChemistry,10thEd.,OxfordUniversityPress,2014.
d) Day,M.C.andSelbin,J.TheoreticalInorganicChemistry,ACSPublications,1962.
Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits: 2

List of Experiments:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-BaseTitrations

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* 6^{th} *Ed.,* Pearson, 2009.

PHYSICAL CHEMISTRY-I

Core Corse- 2

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section- A

Gaseous state:

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy ,law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour.

Vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

(20 Lectures)

Section- B

Liquid state:

Qualitative treatment of the structure of the liquid state; Radial distribution

function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water. **(10 Lectures)**

Section- C

Solid state:

Nature of the solid state, law of constancy of interfacial angles, law of rational indices,Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals. **(12 Lectures)**

Section- D

Ionic equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts .Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts–applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages).Theory of acid–base indicators ;selection of indicators and their limitations.
Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

(18 Lectures)

Suggested Books:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., OxfordUniversityPress (2014).
2. Ball,D.W.*PhysicalChemistry*ThomsonPress,India(2007).
3. Castellan, G. W. *Physical Chemistry* 4thEd. Narosa(2004).
4. Mortimer, R. G. *Physical Chemistry* 3rdEd. Elsevier: NOIDA, UP (2009).
5. Engel, T. & Reid, P. *Physical Chemistry* 3rdEd. Pearson (2013).

CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits: 2

List of Experiments:

1. **Surface tension measurements.**
    a. Determine the surface tension by (i) drop number (ii)drop weight method.
    b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**.
    a. Determination of viscosity of aqueous solutions of (i)polymer (ii)ethanoland (iii) sugar at room temperature.
    b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**
4. **pHmetry**
    a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
    b. Preparation of buffer solutions of different pH
        i. Sodium acetate-acetic acid
        ii. Ammonium chloride-ammonium hydroxide
    c. pH metric titration of (i)strong acid vs. strong base, (ii)weak acid vs. strong base.
    d. Determination of dissociation constant of a weak acid.

Suggested Books:

1. Khosla, B. D.; Garg, V. C. &Gulati, A. *Senior Practical Physical Chemistry,* R. Chand&Co.:NewDelhi(2011).
2. Garland,C.W.;Nibler,J.W.&Shoemaker,D.P.*ExperimentsinPhysicalChemistry* 8^{th}*Ed.*;McGraw-Hill:NewYork(2003).
3. Halpern,A.M.&McBane,G.C.*ExperimentalPhysicalChemistry*3^{rd}*Ed.;*W.H. Freeman&Co.:NewYork(2003).

Environmental Studies

Paper Code: Time Allowed:

Max. Marks: 40 Credits: 2

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 8 marks each and may contain more than one part. Question 1 will be of 8 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be hours.

Section- A

Introduction to environmental studies

- Multidisciplinary nature of environmentalstudies;
- Scope and importance; Need for publicawareness.

Ecosystems

What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems:

a) Forest ecosystem
b) Grassland ecosystem
c) Desert ecosystem
d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

8 Hrs

Section- B

Natural Resources: Renewable and Non-renewable Resources

- Land resources and land use change; Land degradation, soil erosion and desertification.
- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
- Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international &inter-state).
- Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs. 8 Hrs

Biodiversity and Conservation

- Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hotspots
- India as a mega-biodiversity nation; Endangered and endemic species ofIndia
- Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity 8 Hrs

Section – C

Environmental Pollution

- Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution
- Nuclear hazards and human healthrisks
- Solid waste management: Control measures of urban and industrialwaste.
- Environmental legalization and implementation in India.

8 hrs

Environmental Policies & Practices

- Sustainability and sustainable development.
- Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture
- Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act.
- Nature reserves and human wildlife conflicts in Indian context.

7 Hrs

Section – D

Human Communities and the Environment

- Human population growth: Impacts on environment, human health andwelfare.
- Disaster management: floods, earthquake, cyclones andlandslides.
- Environmental movements: Chipko, Silent valley, Bishnois ofRajasthan.
- Environmental ethics: Role of Indian and other religions and cultures inenvironmental conservation.

6 Hrs

Field work

- Visit to an area to document environmental assets: river/ forest/ flora/fauna,etc.
- Visit to a local pollutedsite-Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds and basic principles ofidentification.
- Study of simple ecosystems-pond, river, Delhi Ridge,etc.

5 Hrs

Suggested Books:

1 Bharucha, E. 2003, Textbook for Environmental Studies, University Grants Commission, New Delhi and BharatiVidyapeeth Institute of Environmental Education and Research, Pune. 361.

2 Carson, Rachel. 1962. Silent Spring (Boston: Houghton Mifflin, 1962), Mariner Books, 2002

3 Economy, Elizabeth. 2010. The River Runs Black: The Environmental Challenge to China's Future.

4 Gadgil, M. &Ramachandra, G. 1993. *This fissured land: an ecological history of India*. Univ of California Press.

5 Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.

6 Grumbine, R. Edward, and Pandit, M.K. Threats from India's Himalaya dams. *Science* 339.6115 (2013): 36-37.

Semester II

Core Course- 3

ORGANIC CHEMISTRY- I

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section- A

Basics of Organic Chemistry

Organic Compounds: Classification and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. **(10 Lectures)**

Section- B

Stereochemistry:

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism :cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. **(15 Lectures)**

Section- C

Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions.Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylicbromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. **(20 Lectures)**

Section- D

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Aromatic Hydrocarbons

Aromaticity: Hückel'srule, aromatic character of arenes, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

(15 Lectures)

Suggested Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd.(PearsonEducation).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
3. Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of NaturalProducts)*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
4. Eliel, E. L. &Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
5. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7thEd. Cengage Learning India Edition,2013

CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits:2

List of Experiments:

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
    a. Water
    b. Alcohol
    c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds(Kjeldahlmethodandelectricallyheatedmeltingpointapparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than100°Cbydistillationandcapillarymethod)
6. Chromatography
    a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
    b. Separation of a mixture of two sugars by ascending paper chromatography
    c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography(TLC)

Suggested Books:

1. Mann,F.G.&Saunders,B.C.*PracticalOrganicChemistry,*PearsonEducation (2009)
2. Furniss,B.S.;Hannaford,A.J.;Smith,P.W.G.;Tatchell,A.R.*PracticalOrganic Chemistry,5thEd.,*Pearson(2012)

PHYSICAL CHEMISTRY- II

Core Course: 3

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section- A

Chemical Thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

(24 Lectures)

Section- B

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T,V,P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Systems of Variable Composition:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

(20 Lectures)

Section- C

Chemical Equilibrium:

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_C and K_X. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

(8 Lectures)

Section- D

Solutions and Colligative Properties:

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i)relative lowering of vapour pressure, (ii) elevation of boiling point, Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

(8 Lectures)

Suggested Books:

1. Peter,A.&Paula,J.de.*PhysicalChemistry*10th Ed.,OxfordUniversityPress(2014).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa(2004).
3. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
4. McQuarrie,D.A.&Simon,J.D.*MolecularThermodynamics*VivaBooksPvt.Ltd.: NewDelhi(2004).
5. Assael,M.J.;Goodwin,A.R.H.;Stamatoudis,M.;Wakeham,W.A.&Will,S.
6. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
7. Levine, I .N. *Physical Chemistry* 6th Ed., Tata McGraw Hill (2010).
8. Metz,C.R.*2000solvedproblemsinchemistry,*SchaumSeries(2006)

CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits:2

List of Experiments:

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) Determination of basicity/proticity of a poly protic acid by the thermo chemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(f) Determination of enthalpy of hydration of copper sulphate.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Suggested Books

1. Khosla, B. D.; Garg, V. C. &Gulati, A., *Senior Practical Physical Chemistry,* R. Chand&Co.:NewDelhi(2011).
2. Athawale, V. D. &Mathur, P. *Experimental Physical Chemistry* New Age International:NewDelhi(2001).

English Communication

Paper Code: Time Allowed:
Max. Marks: 40 Credits: 2

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 8 marks each and may contain more than one part. Question 1 will be of 8 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be hours.

Section-A

Introduction: Theory of Communication, Types and modes of Communication

Language of Communication

- Verbal and Non-verbal
  (Spoken and Written)
- Personal, Social and Business
- Barriers and Strategies
- Intra Personal, Inter Personal and Group Communication

Section-B

Speaking Skills

- Monologue
- Dialogue
- Group Discussion
- Effective Communication/ Mis- Communication
- Interview
- Public Speech

Section-C

Reading and Understanding

- Close Reading
- Comprehension
- Summary Paraphrasing
- Analysis and Interpretation
- Translation(from Indian language to English and vice-versa)

- Literary/Knowledge Texts

Section-D

Writing Skills

- Documenting
- Report Writing
- Making notes
- Letter Writing

Recommended Readings:

1. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brat iBiswas
2. Fluency in English Part II Oxford University Press, 2006
3. Business English, Pearson, 2008.

Basic Mathematics

Paper Code: Time Allowed:
Max. Marks: 40 Credits: 0

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 8 marks each and may contain more than one part. Question 1 will be of 8 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be hours.

UNIT-I

Matrices & Determinants: Definition, Types of Matrix, Algebra of Matrix, Transpose of Matrix, Adjoint of Matrix, Inverse of Matrix; Determinants; Solution of system of equations using Cramer's Rule;

UNIT-II

Limits &Continuity; Differentiation: Differentiation of sums, products & Quotients, Chain rule, Composite Differentiation; Simple Application of Differentiation

UNIT-III

Integration: Indefinite Integral, Method of Integration by substitution, by parts, by partial fraction; Simple application of integration;

UNIT-IV

Sets, Venn diagram and its applications, Operations on sets, Cartesian product of sets; Measure of Central Tendency; Simple AP/GP problems;

Suggested Readings:

1. Business Mathematics For B.B.A: Janardian Dinodia & Dalip Kumar; Jeevansons Publications
2. Business Mathematics: Zameeruddin, Q; Vikash Publishing House Pvt. Ltd.
3. Mathematics-Volume II: R. D. Sharma; Dhanpat Rai Publications
4. Business Mathematics: Trivedi, K; Pearson Education India
5. NCERT Mathematics(XI,XII)

Generic Elective Papers 1

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section A

Inorganic Chemistry-1

Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2,Schrödinger equation for hydrogen atom..Radial and angular nodes and their significance.Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(14 Lectures)

Section- B

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole

moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonalplanar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.
Concept of resonance and resonating structures in various inorganic and organic compounds.
MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristicsfor*s-s*,*s-p*and*p-p*combinationsofatomicorbitals,nonbondingcombination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2ndperiods(including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(16 Lectures)

Section C

Organic Chemistry-1

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.
Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.
Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures)

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis-trans* nomenclature; CIP Rules: R/S (for up to 2chiral carbon atoms) and E/Z Nomenclature (for up to two C=C systems)

(10 Lectures)

Section- D

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:*Free radical Substitution: Halogenation.

Alkenes: (Upto5Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

(12 Lectures)

Reference Books:

1. Lee,J.D.*ConciseInorganicChemistry*ELBS,1991.
2. Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas,B.E.,McDaniel,D.H.&Alexander,J.J.*ConceptsandModelsinInorganic Chemistry*,JohnWiley&Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. &Medhi, O.K. *Inorganic Chemistry: PrinciplesofStructureandReactivity*,PearsonEducationIndia,2006.
5. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry,* John Wiley&Sons(2014).
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,2013.
7. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi(1988).
8. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
9. Finar,I.L.*OrganicChemistry*(Vol.I&II),E.L.B.S.
10. Morrison,R.T.&Boyd,R.N.*OrganicChemistry*,Pearson,2010.
11. Bahl,A.&Bahl,B.S.*AdvancedOrganicChemistry,*S.Chand,2010.

GE LAB

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits: 2

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.

2. Estimation of oxalic acid by titrating it with $KMnO_4$.

3. Estimationofwaterofcrystallizationin Mohr'ssaltbytitratingwith $KMnO_4$.

4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

5. Estimation of Cu(II)ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements)

2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination o ftwo compounds to be given)

(a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography Identify and separate the sugars present in the given mixture by paper chromatography.

Suggested Books:

1. Svehla,G.*Vogel'sQualitativeInorganicAnalysis*,PearsonEducation,2012.
2. Mendham,J.*Vogel'sQuantitativeChemicalAnalysis*,Pearson,2009.
3. Vogel,A.I.,Tatchell,A.R.,Furnis,B.S.,Hannaford,A.J.&Smith,P.W.G.,*Textbook ofPracticalOrganicChemistry*,Prentice-Hall,5thedition,1996.
4. Mann,F.G.&Saunders,B.C.*PracticalOrganicChemistry*Orient-Longman,1960.

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.

2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

Section- A

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry.Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(10 Lectures)

Section- B

Chemical Equilibrium:

Free energy change in a chemical reaction.Thermodynamic derivation of the law of chemical equilibrium.Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases. **(6 Lectures)**

Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. **(10 Lectures)**

SECTION – C

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.

Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation, Williamson's ether synthesis. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer&Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

17 Hrs

SECTION - D

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Alcohols: Preparation: Preparation of 1o, 2o and 3o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO3).Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumenehydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer - Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: From acid chlorides and from nitriles.

Reactions: Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishner reduction.Meerwein-PondorffVerley reduction.
15 Hrs

Suggested Books:

1. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. 2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. 3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. 4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. 5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. 6. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. 7. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
8. 8. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
9. 9. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
10. 10. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
11. 11. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours

Max. Marks: 50 Credits: 2

I. Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.

2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

3. Determination of enthalpy of ionization of acetic acid.

4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).

5. Determination of enthalpy of hydration of copper sulphate.

II. Ionic Equilibria: pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

III. Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations of organic compounds – Iodoform and Glucosazone

Reference Books

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

3. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Semester III
CC-5

INORGANIC CHEMISTRY II: s and p block elements

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. **(18 Hours)**

SECTION - B

Chemistry of s and p Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(**20 Hours)**

SECTION - C

Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6. Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

(10 Hours)

SECTION - D

Inorganic Polymers:
Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes, Borazines, silicates and phosphazenes, and polysulphates.

(12 Hours)

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. &Earnshaw. Chemistry of the Elements, ButterworthHeinemann. 1997.
- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
  Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

Inorganic Chemistry II Lab

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits- 2

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Complexometric titrations using disodium salt of EDTA

(i) Estimation of Mg^{2+} , Zn^{2}+
(ii Estimation of Ca^{2+} by substitution method

(C) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2

(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$

(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

Reference Books:

Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

CC 6

ORGANIC CHEMISTRY II: Oxygen containing Functional groups

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N^1, S_N^2 and S_N^i mechanisms with stereochemical aspects and effect of solvent etc.; Nucleophilic substitution vs elimination.
Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_N^{Ar}, Benzyne mechanism.
Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.
Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

(15 Hours)

SECTION - B

Alcohols, Phenols, Ethers and Epoxides:

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

(15 Hours)

SECTION - C

Carbonyl Compounds:

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen- Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);
Addition reactions of unsaturated carbonyl compounds: Michael addition.
Active methylene compounds: Keto-enoltautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate. **(15 Hours)**

SECTION - D

Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic

acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of Nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromide degradation and Curtius rearrangement.

Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids. **(15 Hours)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

Organic Chemistry II Lab

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. **Organic preparations**:
   i) Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
      a. Using conventional method.
      b. Using green approach
   ii) Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.
   iii) Oxidation of ethanol/ isopropanol (Iodoform reaction).
   iv) Bromination of any one of the following
      a) Acetanilide by conventional methods
      b) Acetanilide using green approach (Bromate-bromide method)
   v) Nitration of any one of the following:
      i) Acetanilide/nitrobenzene by conventional method
      ii) Salicylic acid by green approach (using ceric ammonium nitrate).
   vi) Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
   vii) Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
   viii) Hydrolysis of amides and esters.
   ix) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
   x) S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
   xi) Aldol condensation using either conventional or green method.
   xii) Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CC 6

PHYSICAL CHEMISTRY III Phase Equilibria & Chemical Kinetics

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Phase Equilibria:

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solidliquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.
Three component systems, water-chloroform-acetic acid system, triangular plots.

(14 Hours)

SECTION-B

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.
Nernst distribution law: its derivation and applications. **(16 Hours)**

SECTION-C

Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

(15 Hours)

SECTION-D

Catalysis:

Types of catalysts, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis- Menten mechanism, acid-base catalysis.

Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

(15 Hours)

Reference Books:

- Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

PHYSICAL CHEMISTRY III LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
    a. simple eutectic and
    b. congruently melting systems.
III. Distribution of acetic/ benzoic acid between water and cyclohexane.
IV. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

V. Study the kinetics of the following reactions.
1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
    a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption
1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEC- I

BASIC ANALYTICAL CHEMISTRY

Paper Code: Time Allowed: 3 Hours
Max. Marks: 50 Credits: 2

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 8 marks each and may contain more than one part. Question 1 will be of 8 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION – A

Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.
Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators.

a. Determination of pH of soil samples. b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration. (8 Hours)

SECTION – B

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample. b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. b. Analysis of preservatives and colouring matter. (9 Hours)

SECTION – C

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. a. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}). b. To compare paint samples by TLC method. Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible). (6 Hours)

SECTION – D

Analysis of cosmetics: Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration. **Suggested Applications (Any one):**

a. To study the use of phenolphthalein in trap cases. b. To analyze arson accelerants. c. To carry out

analysis of gasoline.

Suggested Instrumental demonstrations:

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink (8 Hours)

Reference Books:

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.
2. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
5. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
10. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Prentice Hall.
11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995)

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & ORGANIC CHEMISTRY
(GE- 3)
(GENERIC ELECTIVE PAPERS FOR OTHER DEPARTMENTS/DISCIPLINES)
SEMESTER III

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION - A

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $NaCl$-H_2O and Mg-Zn only). (15 Hours)

SECTION - B

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only). (15 Hours)

SECTION – C

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Carboxylic acids (aliphatic and aromatic) - Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction.
Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) - Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their inter conversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons - Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, reaction with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.(15 Hours)

SECTION - D

Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and Electrophoresis. **Reactions of Amino acids:** ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharide. Structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation. (15 Hours)

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
10. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & ORGANIC CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

I. Distribution Law

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I\ (aq) \rightleftharpoons I_3\ (aq)$

$Cu^{2+}(aq) + xNH_2(aq) \rightleftharpoons [Cu(NH_3)x]^{2+}$

II. Conductance

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
   i) Strong acid vs. strong base
   ii) Weak acid vs. strong base

Or

III. Potentiometry

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Potassium dichromate vs. Mohr's salt

IV. Organic Chemistry

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Any Two of the following:

   i) Separation of amino acids by paper chromatography
   ii) Determination of the concentration of glycine solution by formylation method.
   iii) Titration curve of glycine
   iv) Action of salivary amylase on starch
   v) Effect of temperature on the action of salivary amylase on starch.
   vi) Differentiation between a reducing and a non reducing sugar.

Reference Books:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

Semester IV
CC-8
INORGANIC CHEMISTRY-III Coordination Chemistry

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Coordination Chemistry:

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δ_o, Δ_t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. **(15 Hours)**

SECTION-B

Transition Elements:
General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer &Bsworth diagrams).Difference between the first, second and third transition series.

(15 Hours)

SECTION-C

Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Lanthanides and Actinides: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides and actinides (ion-exchange method only).

(13 Hours)

SECTION-D

Bioinorganic Chemistry:

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace elements. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron. **(17 Hours)**

Reference Books:

- Purcell, K.F &Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
- Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.

- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. &Earnshaw A. Chemistry of the Elements, ButterworthHeinemann, 1997.

INORGANIC CHEMISTRY III LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

Gravimetric Analysis:

i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
iv. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$.
ii. Cis and trans Potassium dioxalatodiaquachromate (III) $K[Cr(C_2O_4)_2.(H_2O)_2]$.
iii. Tetraamminecarbonatocobalt (III) ion
iv. Potassium tris(oxalate)ferrate(III).

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)

Reference Book:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

CC-9
ORGANIC CHEMISTRY-III Heterocyclic Chemistry

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications. **(15 Hours)**

SECTION-B

Polynuclear Hydrocarbons

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons. **(10 Hours)**

SECTION-C

Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis,

Friedlander's synthesis, Knorr quinoline synthesis, DoebnerMiller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Derivatives of furan: Furfural and furoic acid. **(15 Hours)**

SECTION-D

Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action

Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine.Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **(13 Hours)**

Terpenes

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol. **(7 Hours)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly& Sons (1976).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

ORGANIC CHEMISTRY III LAB

TIME ALLOWED: 03 HOURS
Max Marks: 50 Credits - 2

2. Detection of extra elements.

3. Functional group test for nitro, amine and amide groups.

4. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, amides and carbohydrates).

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

CC-10
PHYSICAL CHEMISTRY-IV Electrochemistry

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Conductance - I

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. **(15 Hours)**

SECTION-B

Conductance - 2

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts. **(15 Hours)**

SECTION-C

Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different

kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone- hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). **(16 Hours)**

SECTION-D

Electrical & Magnetic Properties of Atoms and Molecules:

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation. **(14 Hours)**

Reference Books:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

PHYSICAL CHEMISTRY IV LAB

TIME ALLOWED: 03 HOURS
Max Marks: 50 **Credits - 2**

Conductometry

I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
   a. Strong acid vs. strong base
   b. Weak acid vs. strong base
   c. Mixture of strong acid and weak acid vs. strong base
   d. Strong acid vs. weak base

Potentiometry

I. Perform the following potentiometric titrations:
   a) Strong acid vs. strong base
   b) Weak acid vs. strong base
   c) Dibasic acid vs. strong base
   d) Potassium dichromate vs. Mohr's salt

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co. New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed. McGraw-Hill, New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co. New York (2003).

SEC- II
FUEL CHEMISTRY
&
CHEMISTRY OF COSMETICS & PERFUMES

Paper Code: Time Allowed: 3 Hours
Max. Marks: 50 Credits: 2

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 8 marks each and may contain more than one part. Question 1 will be of 8 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.
Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. (9 Hours)

SECTION-B

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination. (9 Hours)

SECTION-C

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. (6 Hours)

SECTION-D

Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone. (6 Hours)

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
4. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990). 2.
5. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
6. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

(GE- 4)

TRANSITION METAL &COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

(GENERIC ELECTIVE PAPERS FOR OTHER DEPARTMENTS/DISCIPLINES)

SEMESTER IV

Paper Code: Time Allowed: 3 Hours

Max. Marks: 75 Credits: 4

Note for Examiners and Students:

1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION - A

Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanides and actinides: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides and actinides (ion exchange method only).

Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC nomenclature of coordination compounds. (16 Hours)

SECTION - B

Crystal Field Theory

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of CF splitting. Spectrochemical series. Comparison of CF Splitting for Octahedral and tetrahedral complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination. (14 Hours)

SECTION - C

Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative

treatment only).

Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). (16 Hours)

SECTION - D

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X– Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.
Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). (14 Hours)

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt.Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
7. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
8. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
9. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

INORGANIC CHEMISTRY III LAB

TIME ALLOWED: 03 HOURS Max Marks: 50

Credits - 2

Gravimetric Analysis:

v. Estimation of nickel (II) using Dimethylglyoxime (DMG).
vi. Estimation of copper as CuSCN
vii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
viii. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Inorganic Preparations:

v. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$.
vi. Cis and trans Potassium dioxalatodiaquachromate (III) $K[Cr(C_2O_4)_2.(H_2O)_2]$.
vii. Tetraamminecarbonatocobalt (III) ion
viii. Potassium tris(oxalate)ferrate(III).

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)

Reference Book:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

Semester V
CC-5

ORGANIC CHEMISTRY IV: Biomolecules

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Nucleic Acids
Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Amino Acids, Peptides and Proteins
Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis;

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

(25 Hours)

SECTION - B

Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

(16 Hours)

SECTION - C

Concept of Energy in Biosystems

Cells obtain energy by the oxidation of foodstuff (organic molecules).
Introduction to metabolism (catabolism, anabolism).
ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD^+, FAD.
Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types.

(7 Hours)

SECTION - D

Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

(12 Hours)

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

Organic Chemistry IX Lab

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits- 2

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Reference Books:

- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. V. Quantitative Organic Analysis, Pearson.

CC 7

PHYSICAL CHEMISTRY V: QUANTUM CHEMISTRY & SPECTROSCOPY

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION -A

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

(12 Hours)

SECTION – B

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).
Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules

(12 Hours)

SECTION - C

Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.
Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of

diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy

Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre issociation, calculation of electronic transitions of polyenes using free electron model.

(17 Hours)

SECTION – D

Nuclear Magnetic Resonance (NMR) spectroscopy:

Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: It's principle and hyperfine structure, ESR of simple radicals.

Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence **(19 Hours)**

Reference Books:

- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
- House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
- Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).

Physical Chemistry XII Lab

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$ in a solution of unknown concentration

II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.

III. Study the kinetics of iodination of propanone in acidic medium.

IV. Determine the amount of iron present in a sample using 1,10-phenathroline.

V. Determine the dissociation constant of an indicator (phenolphthalein).

VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

VII. Analyse the given vibration-rotation spectrum of HCl(g)

Reference Books

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw- Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

DSE – 1
ANALYTICAL METHODS IN CHEMISTRY

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Qualitative and quantitative aspects of analysis:
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Optical methods of analysis:
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry*:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;
Basic principles of quantitative analysis*:* estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

(15 Hours)

SECTION-B

Optical methods of analysis:

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes **using Job's method of continuous variation and mole ratio method.**
Infrared Spectrometry*:* Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.
Structural illustration through interpretation of data, Effect and importance of isotope substitution.
Flame Atomic Absorption and Emission Spectrometry*:* Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(16 Hours)

SECTION-C

Thermal methods of analysis:
Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical methods:
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Separation techniques:
Solvent extraction: Classification, principle and efficiency of the technique.
Mechanism of extraction: extraction by solvation and chelation.
Technique of extraction: batch, continuous and counter current extractions.
Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non aqueous media.

(15 Hours)

SECTION-D

Chromatography: Classification, principle and efficiency of the technique.
Mechanism of separation: adsorption, partition & ion exchange.
Development of chromatograms: frontal, elution and displacement methods.
Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.
Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC)

(14 Hours)

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
- Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
- Ditts, R.V. Analytical Chemistry – Methods of separation.

ANALYTICAL METHODS IN CHEMISTRY LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

I. Separation Techniques

1. Chromatography:
(a) Separation of mixtures
(i) Paper chromatographic separation of Fe3+, Al3+, and Cr3+.
(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry
(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
4. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.
5. Analysis of soil:
(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium, magnesium, phosphate, nitrate
6. Ion exchange:
(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2 Structural characterization of compounds by infrared spectroscopy.
3 Determination of dissolved oxygen in water.
4 Determination of chemical oxygen demand (COD).
5 Determination of Biological oxygen demand (BOD).
6 Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
- Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.

DSE 2
INDUSTRIAL CHEMICALS AND ENVIRONMENT

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(14 Hours)

SECTION-B

Industrial Metallurgy

General Principles of Metallurgy - Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.
Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process. Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

Environment and its segments: Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

(16 Hours)

SECTION-C

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc.

Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water. **(16 Hours)**

SECTION-D

Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry

(14 Hours)

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- K. De, Environmental Chemistry: New Age Inter0national Pvt., Ltd, New Delhi.
- S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, Environmental Chemistry, CRC Press (2005).
- G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
- Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

INDUSTRIAL CHEMICALS AND ENVIRONMENT LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt. Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

CC 6

INORGANIC CHEMISTRY IV Organometallic Chemistry

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Theoretical Principles in Qualitative Analysis (H_2S Scheme)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

(12 Hours)

SECTION-B

Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.
Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

. **(14 Hours)**

SECTION-C

Organometallic Compounds

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.
Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(12 Hours)

SECTION-D

Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine, Cisplatin as an anti-cancer drug. Iron and its application in bio-systems, Haemoglobin, Myoglobin; Storage and transfer of ion.

Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:
1.Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

(22 Hours)

Reference Books:

1. Vogel, A.I. *Qualitative Inorganic Analysis*, Longman, 1972
2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-03-07.
3. Cotton, F.A. G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,
4. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson,2006.
5. Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.*, John Wiley and Sons, NY, 1994.
7. Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements, Elsevier 2nd Ed*, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
8. Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.
9. Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
10. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
11. Basolo, F. & Person, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.*, John Wiley & Sons Inc; NY.
12. Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
13. Miessler, G. L. & Donald, A. Tarr, *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
14. Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.
15. Crabtree, Robert H. *The Organometallic Chemistry of the Transition Metals*. *J* New York, NY: John Wiley, 2000.
16. Spessard, Gary O., &Gary L. Miessler. *Organometallic Chemistry*. Upper Saddle River, NJ: Prentice-Hall, 1996

INORGANIC CHEMISTRY XIII LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}
Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3)
OR combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-.

Spot tests should be done whenever possible.

i) Measurement of 10 Dq by spectrophotometric method
ii) Verification of spectrochemical series.
iii) Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
iv) Preparation of acetylacetanato complexes of Cu2+/Fe3+. Find the λ max of the complex.
v) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
2. Marr & Rockett Inorganic Preparations.

CC 7

ORGANIC CHEMISTRY V SPECTROSCOPY

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Organic Spectroscopy
General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy*:* Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy*:* Fundamental and non-fundamental molecular vibrations IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

NMR Spectroscopy*:* Basic principles of Proton Magnetic Resonance chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpetation of NMR spectra of simple compounds.
Applications of IR, UV and NMR for identification of simple organic molecules.

(24 Hours)

SECTION-B

Carbohydrates

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen
.

(16 Hours)

SECTION-C

Dyes

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

(8 Hours)

SECTION-D

Polymers

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

(12 hours)

Reference Books:

1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
9. Kemp, W. *Organic Spectroscopy*, Palgrave

ORGANIC CHEMISTRY XIV LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars. 39
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Reference Books:
• Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
• Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
• Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
• Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
• Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chem

DSE III
INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Introduction to spectroscopic methods of analysis

Introduction to spectroscopic methods of analysis: Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

Molecular spectroscopy

Infrared spectroscopy: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection. **(14 Hours)**

SECTION-B

UV-Visible/ Near IR – emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoaccoustic, fluorescent tags)

(14 Hours)

SECTION-C

Separation techniques Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis. Immunoassays and DNA techniques
Mass spectroscopy: Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation). **(16 Hours)**

SECTION-D

Elemental analysis: Mass spectrometry (electrical discharges). Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences). (8 Lectures)

NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spincoupling, Applications.
Electroanalytical Methods: Potentiometry & Voltammetry
Radiochemical Methods , X-ray analysis and electron spectroscopy (surface analysis)

(16 Hours)

Reference Books:

• Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN
0-495-01201-7).
• Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle
• P.W. Atkins: Physical Chemistry.
• G.W. Castellan: Physical Chemistry.
• C.N. Banwell: Fundamentals of Molecular Spectroscopy. • Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
• W.J. Moore: Physical Chemistry.

INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
16. Use of "presumptive tests" for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

At least 10 experiments to be performed.

Reference Books:

- Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).
- Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

DSE IV
POLYMER CHEMISTRY

Paper Code: Time Allowed: 3 Hours
Max. Marks: 75 Credits: 4

Note for Examiners and Students:
1. The question paper will consist of four sections A, B, C & D. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Question 1 will be of 15 marks and consists of short answer type questions of 2 to 3 marks each covering the entire syllabus.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

SECTION-A

Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

(15 Hours)

SECTION-B

Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

(16 Hours)

SECTION-C

Determination of molecular weight of polymers (Mn, Mw, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

Polymer Solution – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

(15 Hours)

SECTION-D

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).
Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)

(14 Hours)

Reference Books:

1. Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, 1981.
2. Odian, G. Principles of Polymerization, 4th Ed. Wiley, 2004.
3. Billmeyer, F.W. Textbook of Polymer Science, 2nd Ed. Wiley Interscience, 1971.
4. Ghosh, P. Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
5. Lenz, R.W. Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1966

POLYMER CHEMISTRY III LAB

Paper Code: Time Allowed: 3 Hours
Max Marks:50 Credits – 2

I. Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
    a. Purification of monomer
    b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile (AIBN)
2. Preparation of nylon 66
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

II. Polymer characterization

1. Determination of molecular weight by viscometry:
    (a) Polyacrylamide-aq.$NaNO_2$ solution
    (b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

***At least 7 experiments to be carried out**

Reference Books:

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013)