3 : CHEMISTRY

The examination in Chemistry of Fifth semester shall comprise of one theory paper, internal assessment and practical examination. Theory paper will be of 3 Hrs. duration and carry 80 marks. The internal assessment will carry 20 marks. The practical examination will be of 6 to 8 hours duration and carry 50 marks.

The following syllabi is prescribed on the basis of six lectures per week and 6 practical periods per batch per week. Each theory paper has been divided into 6 units. There shall be one question in every unit with internal choice for each of 12 marks & one compulsory question covering all the syllabus of Semester-V (8 marks).

Semester- V
5S Chemistry

Total Lectures: 84 ***Marks: 80***

Note: Figures to the right hand side indicate number of lectures.

Unit I **14L**

A) Coordination Compounds-I:

Important terms namely-molecular or addition compounds, double salts, complex ion, ligand, coordination number, central metal ion etc. Werner's theory of coordination and experimental evidences on the basis of conduction data and formation of AgCl precipitate in case of cobaltamines. Sidgwick's electronic interpretation and its drawbacks. Effective atomic number rule. IUPAC rules for nomenclature of coordination compounds. Structural isomerism-ionization, linkage and coordination isomerism in complexes. Geometrical isomerism in octahedral complexes of type Ma_4b_2, Ma_4bc, Ma_3b_3, $M(AA)_2b_2$. Square planar complexes of type Ma_2b_2 and Ma_2bc. Optical isomerism in octahedral complexes of type $Ma_2b_2c_2$, Mabcdef, $M(AA)_3$, $M(AA)_2b_2$ and tetrahedral complexes of type Mabcd and $M(AA)_2$. Optical isomerism in square planar complexes. VB theory as applied to structure and bonding in complexes of 3d series elements (Only 4 and 6 coordinated complexes). Inner and outer orbital complexes. Magnetic properties of complexes of 3d series elements. Limitations of VB theory. **[12]**

B) Chelates:

Definition, classification and applications of chelates in analytical chemistry. **[2]**

Unit II **14L**

A) Coordination compounds-II:

Crystal field theory-postulates of CFT. Crystal field splitting in octahedral and tetrahedral complexes. Factors affecting the magnitude of crystal field splitting in octahedral complexes. Concept of CFSE. Distribution of electrons in t_2g and eg orbitals. High spin and low spin complexes on the basis of Δ_o and pairing energy. **[5]**

B) Electronic spectra of transition metal complexes:

Introduction to spectra. Types of electronic transitions. Selection rules for d-d transitions. Spectroscopic ground terms. Term symbols. Calculation of ground terms. Spectra of octahedral d^1 and d^9 complexes. Orgel diagram for d^1 and d^9 octahedral complexes. Discussion of electronic spectrum of $[Ti(H_2O)_6]^{3+}$complex ion. Spectrochemical series. **[6]**

C) Stability of Complexes:

Factors affecting stability of complexes. Stability of chelates with special reference to chelate effect. Stability constants-stepwise and overall. Thermodynamic and kinetic stability. **[3]**

Unit III – Heterocycles and Organometallics **14L**

A) Heterocycles:

Introduction, 5 and 6 membered heterocycles, orbital picture of pyrrole and pyridine. Modern methods of synthesis. Electrophilic substitution in Pyrrole and Pyridine. Chemical reactions and orientation. Nulceophilic substitution in pyridine. **[6]**

B) Organometallic Compounds:

Introduction, methods of preparation and synthetic applications of organomagnesium, organolithium and organozinc compounds. **[5]**

C) Retrosynthesis: Retrosynthetic analysis and applications

a) Different terms used (Disconnection, synthon, synthetic equivalence, FGI, TM)

b) One group disconnection with examples

c) Retrosynthesis and synthesis of following target molecules:-
i) t- Butyl alcohol ii) Acetophenone iii) Cyclohexene iv) Crotonaldehyde
v) Cyclopentylmethanal vi) Benzoin vii) Benzyl benzoate **[3]**

Unit IV **14L**

A) Polymers:

Introduction, types of polymers, addition and condensation polymers. Synthesis, properties and applications of:
1) Natural and synthetic rubber (Buna –S and Buna –N)
2) Synthetic fibers. Polyamides, Polyesters and Polyacrylates.
3) Plastics: Polyolefins and Polyurethanes. **[4]**

B) Dyes:
Classification of dyes on the basis of structure and on the basis of mode of applications. Preparation and uses of Methyl orange, Congo-Red, Crystal Violet and Alizarin. **[4]**

C) Drugs:
Introduction, Preparation, Drug action and use of Aspirin, Paracetamol, Sulphanilamide and Sulphaguanidine. **[3]**

D) Pesticides:
Introduction, Classification (Insecticides, Herbicides, Fungicides and Rodenticides). Synthesis and uses of a) Malathion b) 2,4-dichlorophenoxy acetic acid (2,4- D). **[3]**

Unit V- Elementary Quantum Mechanics **14L**

(i) Limitations of classical mechanics. Planck's quantum theory (Postulates only). Photoelectric effect (Experiments, Observations and Einstein's explanation). Compton effect and it's explanation.
(ii) L de Broglie hypothesis of matter waves. de Broglie's equation. Heisenberg's uncertainty principle.
(iii) Classical wave equation. Derivation of time independent Schrodinger's wave equation in one dimension and it's extension to a three dimensional space. Well behaved wave function. Physical significance of the wave function (Born interpretation).
(iv) Application of Schrodinger wave equation to a particle in one dimensional box and it's extension to a three dimensional box. Concept of atomic orbitals.
(v) Numericals.

Unit VI- Molecular Spectroscopy **14L**

(i) Electromagnetic radiation. Characterization of EMR in terms of wavelength (λ), frequency (υ), wave number (υ) and energy of photon ($h\upsilon$). Spectrum of electromagnetic radiations.
(ii) Energy level diagram of a molecule indicating electronic, vibrational and rotational transitions.
(iii) Condition for pure rotational spectrum (i.e. microwave active molecules). Selection rule for rotational transitions. Derivation of expression for moment of inertia of a diatomic rotor. Isotope effect. Applications of microwave spectroscopy for the determination of moment of inertia and bond length.
(iv) Condition for exhibiting vibrational spectrum (i.e. IR active molecules). Selection rule for vibrational transitions. Vibrational energy levels of a simple harmonic oscillator. Zero point energy. Position of a spectral line. Determination of force constant of covalent bond.
(v) Raman effect. Raman spectrum of a molecule. Condition for exhibiting Raman spectrum (i.e. Raman active molecules). Selection rule for rotational transitions. Pure rotational spectrum of diatomic molecule. Vibrational Raman spectrum of a diatomic molecule.
(vi) Numericals.

Semester- V
5S Chemistry Practicals

Total Laboratory sessions: 21 **Marks: 50**

Unit I: Inorganic Chemistry Practicals **7 Laboratory sessions**

1. Inorganic preparations:
(a) Preparation of tetramine copper (II) sulphate.
(b) Preparation of hexamine nickel (II) chloride.
(c) Preparation of potassium trioxalatoaluminate (III).
(d) Preparation of Prussian blue.
(e) Preparation of chrome alum.
(f) Preparation of sodium thiosulphate & dithionite.
(g) Preparation of cuprous chloride.

} Comments on its VB structure, magnetic properties and colors.

Unit II- Organic Chemistry Practicals **7 Laboratory sessions**

1) Estimation of acetamide.
2) Estimation of glucose.
3) Estimation of formaldehyde.
4) Estimation of nitro group.
5) Estimation of proteins.
6) TLC/Paper chromatography: Qualitative separation of mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).
7) Steam Distillation (Only demonstration)
   a) Naphthalene from its suspension in water.
   b) Clove oil from cloves

Unit III: Physical Chemistry Practicals **7 Laboratory sessions**

Expt. No. 1: To study conductometric titration of a mixture of strong and week acid (e.g. HCl + CH_3COOH) against a strong base (NaOH). (Standard oxalic acid solution to be prepared by the student).
Expt. No. 2: To determine dissociation constant (Ka) of a week acid (e.g. CH_3COOH) by conductometry.
Expt. No. 3: To study pH metric titration of a strong acid (e.g. HCl) against a strong base (e.g. NaOH) by computer simulation.
Expt. No. 4: To study potentiometric titration of a strong acid (e.g. HCl) against a strong base (e.g. NaOH). (Standard oxalic acid solution to be prepared by the student).
Expt. No. 5: To verify Lambert-Beer Law using $KMnO_4$/ $K_2Cr_2O_7$ solution.

Distribution of Marks for Practical Examination.

Time: 6 – 8 hours	**(One Day Examination)**		**Marks: 50**
Unit – I	: Inorganic Chemistry (Exercise)	……..	12
Unit – II	: Organic Chemistry (Exercise)	……..	12
Unit – III	: Physical Chemistry (Exercise)	……..	12
	Viva-Voce	…….....	07
	Record	…….	07
		Total:	**50**

Semester- VI
6S Chemistry

Total Lectures: 84 ***Marks: 80***

Note: Figures to the right hand side indicate number of lectures.

Unit I : **A) Kinetic Aspects of Metal Complexes:** **14L**

Types of reactions of coordination compounds. Brief idea about substitution reactions. SN^1 dissociative and SN^2 associative mechanism of substitution in octahedral complexes. Labile and inert complexes. Factors affecting lability of complexes viz. arrangement of d-electrons (VB theory), size and charge on central metal ion and geometry of the complexes. Mechanism of substitution reactions in square planar complexes. **[6]**

B) Analytical Chemistry:

1. Colorimetry and Spectrophotometry:

Concept of λ_{max}. Beer-Lambert's law (only statements and final equation-no derivation). Calibration curve and its importance. Validity and limitations of Beer-Lambert's law. Verification of Beer's law. Block diagrams of colorimeter and spectrophotometer with brief description of each component and its function. Difference between colorimeter and spectrophotometer. Application of colorimetric and spectrophotometric technique for determination of concentration of metal ion [Example of determination of copper (II)].

2. Paper Chromatography:

Definition and classification of chromatography. Principle of differential migration. Principle and technique of paper chromatography, R_f value and factors affecting R_f value. **[8]**

Unit II : **A) Organometallic Chemistry:** **14L**

Definition, classification and nomenclature of organometallic compounds. Metal carbonyls-definition and classification. Preparation, properties, structure and bonding in mononuclear carbonyls- $Ni(CO)_4$, $Fe(CO)_5$ and $Cr(CO)_6$. Nature of metal-carbon bond in metal carbonyls. **[5]**

B) Inorganic Polymers:

Definition and classification. Silicones –preparation, properties applications, structure and bonding. Phosphonitrilic halide polymers- preparation, properties, structure and bonding in cyclic polymers. **[5]**

C) Bioinorganic Chemistry:

Essential and trace elements in biological processes. Role of Na^+, K^+, Mg^{2+} and Ca^{2+} ions in biological processes. Metalloporphyrins- Myoglobin and Hemoglobin and their role in oxygen transfer. **[4]**

Unit III : **A) Electronic Spectroscopy:** **14L**

Introduction, radiation source, spectral range, types of electronic transitions, chromophore, auxochrome, bathochromic, hypsochromic, hyperchromic and hypochromic effects. Presentations of spectrum, applications to the structure determination of compounds like dines, aldehydes, ketones and aromatic systems. **[5]**

B) Infrared Spectroscopy:

Types of vibrational modes, stretching and bending, spectrum range, radiation source, presentation of IR spectrum, characteristic frequencies of various groups, Finger print region. Structure of organic compounds (IR spectra of simple compounds: H_2O, CO_2, $CH{\equiv}CH$, CH_3COCH_3). **[5]**

C) Purification of Organic Compounds: Sublimation, crystallization. Paper chromatography: Principle and R_f value. **[4]**

Unit IV : **A) Nuclear Magnetic Resonance Spectroscopy:** **14L**

Introduction, origin of NMR phenomenon, spins of nucleus, spin angular momentum, energy states for proton in the magnetic field, absorption signals in the spectrum. Number of signals, Equivalent and Nonequivalent protons, nuclear shielding and deshielding, chemical shift, delta scale, integration wave, peak area and proton counting, spin-spin splitting, NMR spectra of simple molecules and structural analysis (ethyl bromide, ethyl alcohol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene, acetone and acetophenone, methyl ethyl ether). **[5]**

B) Mass Spectrometry:

Introduction, Theory, Instrumentation, Ion sources (EI, CI, FD, FAB) recording of mass spectrum, molecular ions, fragmentations. Determinations of molecular formula on the basis of mass spectra. **[4]**

C) Quantitative Organic Chemistry

Estimations of C, H, N, S and X (only principles and calculations), Determinations of empirical formula, molecular formula. Problems involving calculations, reactions and spectral data. **[5]**

Unit V : Photochemistry **14L**

(i) Photochemical and thermal reactions.
(ii) Lambert's law (Statement and derivation). Beer's law (Statement and derivation). Reasons for deviations from Beer's law.
(iii) Laws of photochemistry- (a) Grotthus-Draper law (b) Stark-Einstein law.
(iv) Quantum yield of photochemical reaction. Reasons for high and low quantum yields. Experimental determination of quantum yield. Photosensitized reactions.
(v) Kinetics of photochemical decomposition of HI.
(vi) Fluorescence and Phosphorescence. Selection rule for electronic transitions. Internal conversion and Intersystem crossing. Explanation of Fluorescence and Phosphorescence on the basis of Joblonski Diagram.
(vii) Chemiluminescence and Bioluminescence (with examples).
(viii) Numericals.

Unit VI : (A) Electrochemistry **14L**

(i) pH of a soluction and pH scale. Determination of pH of solution using Hydrogen, Quinhydrone and Glass electrodes. Advantages and Disadvantages of these electrodes. pH metric titrations. Determination of pKa of a weak acid by pH metric titration.
(ii) Potentiometric titration. Advantages of Potentiometric titrations. Study of following potentiometric titrations- (a) Acid-Base (b) Redox (c) Precipitation.
(iii) Numericals. **[5]**

(B) Nuclear Chemistry

(i) Composition of nucleus.
(ii) Shell model of the nucleus- Assumptions, Evidences for existences of magic numbers, Advantages and Limitations.
(iii) Liquids drop model of the nucleus- Assumptions, Similarities between nucleus and liquid drop, Advantages and Limitations. Explanation of nuclear fission reaction on the basis of liquid drop model.
(iv) Nuclear force and its explanations on the basis of meson theory.
(v) Representation of a nuclear reaction. Characteristics of a nuclear reaction. Difference between nuclear and chemical reactions. Calculation of Q-value of a nuclear reaction.
(vi) Characteristics of a nuclear fission reaction. Fission yield and Fission yield curve. Fission reaction as an alternative source of energy.
(vii) Characteristics of a nuclear fusion reaction. Thermonuclear reactions as a source of energy of sun and others star. Fusion reactions as a potential future source of energy.
(viii) Applications of radioisotopes in Industry, Agriculture, medicines and biosciences (at least two examples of each type).
(ix) Numericals. **[9]**

Semester- VI
6S Chemistry Practicals

Total Laboratory sessions: 21 **Marks: 50**

Unit I: Inorganic Chemistry Practicals **7 Laboratory sessions**

1. Chromatographic separation of binary mixture containing Cu(II), Co(II) and Ni(II) ions by paper chromatography and determination of R_f values.
2. Estimation of zinc (II) by complexometric titration.
3. Estimation of hardness of water by complexometric titration.
4. Colorimetric or spectrophotometric estimation of copper (II) in commercial copper sulphate sample as ammonia complex.

[**Note**: Standard solutions are to be prepared by the students]

Unit II- Organic Chemistry Practicals **7 Laboratory sessions**

1) Estimation of glycine.
2) Estimation of Ascorbic acid.
3) Determination of equivalent weight of an acid.
4) Determination of Iodine value of an oil.
5) Determination of equivalent weight of ester by saponification.
6) Estimation of free fatty acids in the oil.
7) Chromatographic separation of 2,4- DNP derivative of acetone and butanone-2 using toluene-petroleum ether ($40\text{-}60^0$).
8) Column chromatography (only demonstration)
   a) Separation of fluorescence and methylene blue.
   b) Separation of leaf pigments from spinach leaves.

Unit III: Physical Chemistry Practicals **7 Laboratory sessions**

Expt. No. 1: To determine solubility and solubility product of a sparingly soluble salt (e.g. $BaSO_4$) by conductometry.
Expt. No. 2: To study potentiometric titration of ferrous ammonium sulphate (FAS) against $K_2Cr_2O_7$ solution.
Expt. No. 3: To study potentiometric titration of KCl solution against $AgNO_3$ solution.
Expt. No. 4: To determine dissociation constant (Ka) of a dibasic or tribasic acid by pH metry.
Expt. No. 5: To determine specific rotation of the optically active compound by polarimeter.

Distribution of Marks for Practical Examination.

Time: 6 – 8 hours (One Day Examination)		**Marks: 50**
Unit – I : Inorganic Chemistry (Exercise)	……..	12
Unit – II : Organic Chemistry (Exercise)	……..	12
Unit – III: Physical Chemistry (Exercise)	……..	12
Viva-Voce	…….....	07
Record	…….	07
		Total: 50

Books Recommended: (Common for Semester V and Semester VI)

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand & Co., Delhi.
2. Text book of Inorganic Chemistry by A.K. De, Wiley East Ltd.
3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan- S. Chand & Co.
4. Modern Inorganic Chemistry by R.C. Agrawal, Kitab Mahal.
5. Instrumental Methods of analysis by Chatwal and Anand, Himalaya Publishing House.
6. Concise Inorganic Chemistry by J.D. Lee, ELBS.
7. Inorganic Chemistry by J.E. Huheey- Harper & Row.
8. Fundamental concepts of Inorganic Chemistry by E.S. Gilreath, McGraw Hill book Co.
9. Modern Inorganic Chemistry by W.L. Jolly, McGraw Hill Int.
10. Chemistry Facts, Patterns & Principles by Kneen, Rogers and Simpson, ELBS.
11. Theoretical Principles of Inorganic Chemistry by G.S. Manku, Tata McGraw Hill.
12. Inorganic complex compounds by Murmann, Chapman & Hall.
13. Text book of Inorganic Chemistry by K.N. Upadhyaya, Vikas Publishing House, Delhi.
14. Advanced Practical Inorganic Chemistry by Gurdeep Raj, Goel Pulishing House, Meerut.
15. Co-ordination Chemistry by D. Banerjee, TMH Publication.
16. Text book of Inorganic Chemistry by B.J. Joshi, P.J. Bahad, P.R. Mandlik, R.M. Kedar, C.B. Deshpande, V.V. Parhate published by Amravati University Chemistry Teachers Association with Bokey Prakashan, Amravati.
17. Text book of Inorganic Chemistry by Bhadange, Pagariya, Deshmukh, Joshi, Bombatkar, Mandlik, Bokey Prakashan, Amravati.
18. Organic Chemistry by R.T. Morrison & R.T. Boyd, 6th edition, PHI.
19. Organic Chemistry by Pine, 5th edition.
20. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern.
21. Organic Chemistry by S.K. Ghosh.
22. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
23. Spectroscopy of Organic Compounds by P.S. Kalsi.
24. Stereochemistry and mechanism through solved problems by P.S. Kalsi.
25. Organic Chemistry by TWG Solomons, 4th edition, John Wiley.
26. Hand Book of Organic Analysis by H.J. Clarke, Arnold Heinmen.
27. Text book of Practical Organic Chemistry by A. I. Vogel.
28. Text book of Organic Chemistry by P.R. Rajput, S.N. Bhosale, Y.K. Meshram, V.G. Thakre, Dr. S.P. Deshmukh, A.R. Mankar, published by Amravati University Chemistry Teachers Association with Bokey Prakashan, Amravati.
29. Text book of Organic Chemistry by P.S. Kalsi published by Macmilllan India Ltd., 1999, Delhi.
30. Practical Organic Chemistry by F.G. Mann, B.C. Saunders, Orient Longman.
31. Comparative Practical Organic Chemistry (Qualitative Analysis) by V.K. Ahluwalia and Sunita Dhingra, Orient Longman.
32. Comprehensive Practical Organic Chemistry (Preparation and Qualitative Analysis) by V.K. Ahluwalia and Renu Agrawal, Orient Longman.
33. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi.
34. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn.
35. Principles of Physical Chemistry: Maron and Prutton.
36. Principles of Physical Chemistry: Puri, Sharma and Pathaniya.
37. Physical Chemistry: P.W. Atkins, 4th Edn.
38. Text book of Physical Chemistry: P.L. Sony, O.P. Dharma.
39. Physical Chemistry: Levine.
40. Practical Physical Chemistry: Palit and De.
41. Practical Physical Chemistry: Yadao.
42. Practical Physical Chemistry: Khosla.
43. Laboratory Mannual of Physical Chemistry: W.J. Popiel.
44. Practical Chemistry: Dr. S.B. Lohiya, Bajaj publication, Amravati.
45. Text book of Physical Chemistry by S.B. Phadke, G.N. Chaudhari, S.S. Kabra, R.G. Bhangale, A.B. Patil, S.K. Rithe published by Amravati University Chemistry Teachers Association with Bokey Prakashan, Amravati.

List of equipments/apparatus required for the Chemistry Practicals for B.Sc.

1. Abbe's Refractometer	02 nos./batch
2. Viscometer	10 nos./batch
3. Stalagmometer	10 nos./batch
4. Melting Point Apparatus	10 nos./batch
5. Thermometer 0-360^{o}C	20 nos./batch
6. Thermometer 0-110^{o}C	20 nos./batch
7. Analytical balance	15 nos./batch
8. Weight box	15 nos./batch