बिलासपुर विश्वविद्यालय, बिलासपुर (छ.ग.) से संबद्ध
समस्त स्नातकोत्तर (शासकीय एवं अशासकीय) महाविद्यालयों में
सत्र् 2016-17 से लागू सेमेस्टर पद्धति के अनुसार
नियमित छात्रों के लिए
सेमेस्टर पाठ्यक्रम

एम.एससी. (मास्टर ऑफ साइंस)
M.Sc. (Master of Science)

विषय - रसायन शास्त्र
Subject – Chemistry

बिलासपुर विश्वविद्यालय, बिलासपुर (छ.ग.)
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Bilaspur University Bilaspur

Syllabus

Chemistry

Group- B

M.Sc.

Semester- I

2016-17

BILASPUR UNIVERSITY, BILASPUR (C.G.)
SEMESTER SYSTEM COURSE STRUCTURE & MARKS SCHEME
FOR M. Sc. CHEMISTRY
(Two Years Course 2016-18)

- Candidate will be required 36% of marks to pass external and internal examination separately.
- Total No. of Semester-4

SEMESTER- I

(a) Theory Marks-

S.No	Paper	External Marks	Internal Assessment Marks			Total
			One Unit Test	One Seminar/ Assignment	Average	
1.	Inorganic Chemistry	80	20	20	20	100
2.	Organic Chemistry	80	20	20	20	100
3.	Physical Chemistry	80	20	20	20	100
4.	Spectroscopy & Maths/Bio	80	20	20	20	100
	Total					400

(b) Practical Marks-

S.No	Laboratory Course	-	-	-	-	Total
1.	Organic Chemistry	-	-	-	-	100
2.	Analytical Chemistry	-	-	-	-	100
	Total					200

SEMESTER – I Grand Total (a) + (b)= 600

SEMESTER- II

(c) Theory Marks-

S.No	Paper	External Marks	Internal Assessment Marks			Total
			One Unit Test	One Seminar/ Assignment	Average	
1.	Inorganic Chemistry	80	20	20	20	100
2.	Organic Chemistry	80	20	20	20	100
3.	Physical Chemistry	80	20	20	20	100
4.	Spectroscopy & Computer for Chemists	80	20	20	20	100
	Total					400

(d) Practical Marks-

S.No	Laboratory Course	-	-	-	-	Total
1.	Inorganic Chemistry	-	-	-	-	100
2.	Physical Chemistry	-	-	-	-	100
	Total					200

SEMESTER– II Grand Total (c) + (d)= 600

SEMESTER– I + II = 1200

SEMESTER-III

(Note- Paper I & II are compulsory for all groups- A, B & C)

(a) Theory Marks-

S.No	Paper	External Marks	Internal Assessment Marks			Total
			One Unit Test	One Seminar/ Assignment	Average	
1.	Application of Spectroscopy	80	20	20	20	100
2.	Bio-Inorganic & Bio-organic	80	20	20	20	100
	Group- B					
3.	Physico Organic Chemistry	80	20	20	20	100
4.	Chemistry of Heterocyclic Compounds	80	20	20	20	100
	Total					400

(b) Practical Marks-

S.No	Laboratory Course	-	-	-	-	Total
1.	General Chemistry	-	-	-	-	200
	Total					200

SEMESTER – III Grand Total (a) + (b)= 600

SEMESTER-IV

(c) Theory Marks-

S.No	Paper	External Marks	Internal Assessment Marks			Total
			One Unit Test	One Seminar/ Assignment	Average	
1.	Photochemistry & Solid State Chemistry	80	20	20	20	100
2.	Bio- Physical & Env. Chemistry	80	20	20	20	100
	Group- B					
3.	Medicinal Chemistry	80	20	20	20	100
4.	Chemistry of Natural Product	80	20	20	20	100
	Total					400

(d) Practical Marks-

S.No	Laboratory Course-II	-	-	-	-	Total
1.	Group B Organic Chemistry (Special)	-	-	-	-	200
	Total					200

SEMESTER– IV Grand Total (c) + (d)= 600

SEMESTER– III + IV = 1200

SEMESTER– I + II+III+IV = 2400

M.Sc. CHEMISTRY

SEMESTER- I

Paper- I

INORGANIC CHEMISTRY

Max. M : 80, Min. M:29

Teaching hrs- 60 hrs
Seminar hrs- 08 hrs

Note: - Two question will be asked from each Unit and student will have the choice to attempt any one questions from each unit.

UNIT-I

Stereochemistry and Bonding in Main group Compounds-

VSEPR theory, Walsh Diagram (Tri and Pentatomic-Molecules) dπ -pπ bonds, bent rule and energetics of hybridisation, some simple reaction of covalently bonded, molecules.

UNIT-II

Metal Ligand Bonding-

Limitation of Crystal field Theory, Molecular orbital theory, octahedral, Tetrahedral and square planar complexes. πBonding & molecular orbital theory.

UNIT-III

Electronic spectra of transition metal complexes -

Energy levels in an atom, coupling of orbital angular momentum, determination of ground state term, derivation of term symbols. Electronic spectra of Transition metal complexes, Orgel and Tanabe- sugano-diagrams for Transition metal complexes,

UNIT-IV

(a) Magnetic Properties of transition metal complexes-

Anamalous magnetic moment, Magnetic Exchange coupling and spin crossover, charge transfer spectra.

(b) Symmetry and Matrix representation-

Symmetry Element & Symmetry operation, point Symmetry Group, schoenflies symbols, Matrix Representation of Symmetry Operations, Multiplication Table.

UNIT-V

Group Theory in Chemistry –

Definition of group subgroup, relation between order's of a finite group and its sub group. Conjugate relation and classes., reducible & irreducible representations (Representation for Cn , Cnv , Cnh , Dnv, Dnh etc. groups to be worked out-explicity) The great orthogonality theorem, character of a representation, character table.

Books Suggested :-

1. Group Theory :- Bhattacharya.
2. Advanced Inorganic chemistry:- F.A.Cotton and Wilkinson : John Wiley.
3. Inorganic Chemistry : J.E. Huhey Harpes & Raw
4. Chemistry of the elements: N. N. Greenwood & A Earnshow Pergamon.
5. Inorganic Electronic Spectroscopy :- A. B. P. Lever, Elsevier.
6. Magneto Chemistry :- R.L. Carlin Springer Verlag.
7. Comprehensive Co-ordination Chemistry
   G. Wilkinson, R.D. Gillar's and J.A. Mccleverty Pergamon.
8. Chemistry Applications of Group Theory - F.A. Cotton.

M.Sc. CHEMISTRY SEMESTER – I

PAPER - II

ORGANIC CHEMISTRY

STEREOCHEMISTRY & PERICYCLIC REACTION

Max. M : 80, Min. M:29

Teaching hrs- 60 hrs
Seminar hrs- 08 hrs

Note: - Two questions will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- I

(a) Reaction Intermediates :

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes, nitrenes, and benzynes. Application of NMR in detection of carbocations.

(b) Nature of Bonding in Organic Molecules

Delocalized chemical bonding ,conjugation, cross conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism.

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π molecular orbitals, annulenes, homo-aromaticity, PMO approach.

UNIT- II

Stereochemistry

Conformational analysis of cycloalkanes, decalins ,effect of conformation on reactitity, conformation of sugars, steric strain due to unavoidable crowding. Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythro isomers, methods of resolution, opticalpurity, enantiotopic and diastereotopic atoms, groups and faces, stereospecfic and stereo selective synthesis. Asymmetric synthesis, optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes). chirality due to helical shape. Stereo chemistry of the compoundcontaining nitrogen ,sulphur and phosphorus.

UNIT- III

Reaction Mechanism : Structure and Reactivity :

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, potential

energy diagrams, transition states and intermediates, methods of determining mechanism, isotope effects. Hammett equation and linear free energy relationship, substituent and reaction constants.

UNIT- IV

Pericyclic Reactions :

Molecular orbital symmetry, frontier orbitals of ethylene ,1,3- butadiene, 1,3,5- hexatriene and allyl system. Classification of pericyclic reactions. Wood ward-Hoffmann correlation diagrams, FMO and PMO approach. Electrocyclic reactions, Conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions - antrafacial and suprafacial additions, 4n, 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cyclo additions and cheleotropic reactions. Sigmatropic rearrangements - Suprafacial and antrafacial shifts of H ,sigmatropic shifts involving carbon moieties 3.3 and 5,5- Sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements.Fluxional tautomerism, Ene reaction.

UNIT- V

Molecular rearrangement

General mechanistic approach to molecular rearrangement reactions, carbocation rearrangement- migratory aptitude and memory effects.

Brief study of following rearrangement reactions. Favoroskii, Baeyer-Villigers oxidation, Stork enamine reaction, Shapiro reaction, Sommelet rearrangement, wittig's rearrangement, Grovenstein-Zimmerman rearrangement.

Book Suggested :

1. Advanced Organic Chemistry - Reaction Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry - F.A. Carey and R.K. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry- Peter Syke longman.
4. Structure and Mechanism in organic chemistry - C.K. Ingold, Cornell University Press.
5. Organic Chemistry - R.T. Morrison and R.N. Boyed Prentice - Hall.
6. Modern Organic Reactions - H.O. House, Benzamic.
7. Principles of Organic Synthesis - R.P.C. Norman and J.M. Coxon, Blackie Academic and Professional.
8. Pericyclic Reaction - S.M. Mukherji.
9. Reaction Mechanism in Organic Chemistry - S.M. Mukherji and S.P. Singh Macmilan.
10. Stereochmistry of Organic compounds - D. Nasipuri New age International.
11. Sterochemistry of Organic Compounds - P.S. Kalsi, New Age International.

MSc I –SEMESTER, CHEMISTRY (2016 -17)

PAPER – III

PHYSICAL CHEMISTRY- I

Max. M : 80, Min. M:29

Teaching hrs- 60
Seminar hrs- 08

Note: - Two questions will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- I

QUANTUM CHEMISTRY:

A. Introduction in Exact Quantum Mechanical Result:

The Schrodinger equation and the postulates of quantum mechanics. Discussion of solution of the Schrodinger equation to some model systems, viz. particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

B. Approximate methods:

The various theorem, linear variation principle. Perturbation theory (first order and non – degenerate). Application of variation method and perturbation theory to the Helium atom.

C. Angular Momentum:

Ordinary angular momentum, generalized angular momentum, Eigen functions for angular momentum, Eigenvalue of angular momentum, operator using ladder operators, addition of angular momenta, spin antisymmetry and Pauli Exclusion Principle.

UNIT- II

QUANTUM CHEMISTRY:

A. Electronic Structure of Atoms:

Electronic configuration, Russell – Saunders term and coupling scheme. Slater – Condon parameters, term separation energies of p^n configuration, term separation energies for d^n configurations, magnetic effects: spin – orbital coupling and Zeeman splitting, introduction to the method of self- consistent field, the virial theorem.

B. Molecular Orbital Theory:

Huckel theory conjugated system, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. introduction to extended Huckel theory.

UNIT- III

CHEMICAL DYNAMICS:

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory, ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of

unimolecular reactions. Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov -Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and nuclear magnetic resonance method, Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions).

UNIT- IV

SURFACE CHEMISTRY:

A. ADSORPTION:

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapor pressure of droplets (Calvin equation), and Gibbs adsorption isotherm, estimation of surface area (BET equation), surface film on liquids (Electro- Kinetic phenomenon),catalytic activity of surfaces.

B. MICELLES:

Surface active agents, classification of surface active agents, micellization,hydrophobic interaction, critical micellar concentration (CMC), factor affecting the CMC of surfactants, counter ions binding to micelles, thermodynamics of micellization – phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

UNIT- V

MACROMOLECULES:

Polymer- definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetic of polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination(osmometry, viscometry, diffusion and light scattering method), sedimentation, chain configuration of macro molecules, calculation of various chain structures.

Book Suggested :

1. Physical Chemistry; P. W. Atkins, ELBS.
2. Introduction to Quantum Chemistry; A. K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry; Ira. N. Levine, Prentice Hall.
4. Coulson's Valence; R. Mc Weeny, ELBS.
5. Micelles Theoretical and Applied Aspects; V. Moroi, Plenum.
6. Introduction to Polymer Science; V. R. Gowarikar,N. V. Vishwanathan and J. Sridhar, Wiley Eastern.
7. Physical Chemistry of Surface; A. W. Anderson and A. Gast, Wiley.
8. Surfaces; G. Attard and C.Barnes, Oxford Univ. press.
9. Introduction to Solid state physics. Kittel, Wiley.
10. Crystal structure determination; W. Clegg, Oxford University Press.

MSc I –SEMESTER, CHEMISTRY (2016-17)

Paper – IV

SPECTROSCOPY AND MATHMATICS/BIOLOGY FOR CHEMISTS

Max. M : 80, Min. M:29

Teaching hrs- 60
Seminar hrs- 08

Note: - Two questions will be asked from each Unit and student will have the choice to attempt any one question from each unit.

SECTION- A

UNIT- I

1. SPECTROSCOPY

Unifying Principles :-

Electromagnetic radiation, Interaction of Electromagnetic radiation with matter, absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and Natural line width and natural line broadening. Transition Probability, results of the time dependent perturbation theory, transition moment. Selection rules, intensity of spectral lines. Born-Oppenheimer approximation, Rotational, Vibrational and Electronic Energy Levels.

UNIT- II

A. Microwave Spectroscopy :-

Classification of Molecules, rigid rotor model effect of isotopic substitution on the transition frequencies, Intensities, non rigid rotor. Stark effect, Nuclear and Electron spin Interaction .

B. Raman Spectroscopy :-

Classical & Quantum Theories of Raman effect. Pure rotational, vibrational & vibrational rotational Raman Spectra, Selection rules, Mutual exclusion Principle, Resonance Raman Spectroscopy, Coherent, Antistokes, Raman Spectroscopy (CARS).

UNIT- III

Vibrational Spectroscopy :-

A. Infrared Spectroscopy :- Review of linear harmonic oscillator, vibrational energies of diatomic molecules, Zero point energy, force constant and bond

strengths anhormonicity, Morse Potential Energy Diagram, vibrational, rotation spectroscopy. P.Q.R. branches. Breakdown of Oppenheimer approximation. Vibration of poly atomic molecules. Selection rules, normal modes of vibration, group frequencies overtones hot bands factors affecting the band positions and intensities for IR region.

SECTION- B

Mathematics For Chemists

(for Students without mathematics in B.Sc.)

UNIT- IV

A. Vector and Matrix Algebra

a. Vectors :- Vector dot, cross and triple products etc. The gradient divergence and curl. Vector calculus, gauss Theorem divergence Theorem etc.

b. Matrix Algebra :- Addition and Multiplication, Inverse ,adjoint and transpose of matrices. Special matrices. (Symmetric, Skew symmetric, diagonal, unitary etc) and their properties, matrix equation, Homogeneous,

non Homogeneous linear equations .

B. Differential Calculus :-

Functions, continuity and differentiability rules for differentiation, Applications of differential calculus. Including maxima and minima . Exact & Inexact differentials with their Application to thermodynamics properties.

Integral calculus, basic Rules for Integration , Integration by parts, partial fraction and substitution. Reduction formulae, Applications of integral calculus. Functions of several variables.

UNIT- V

A. Elementary differential equations

Variables - Separable and Exact First-order, differential equation, homogeneous, Exact and linear equation. Applications to Chemical Kinetics, Secular Equilibrium quantum chemistry .

B. Permutation and Probability

Permutations and combinations, probability and probability theorem , probability curves, average, root mean square and most probable errors , examples from kinetic theory of gases.

OR

SECTION- B

BIOLOGY FOR CHEMISTS

(For student without biology in B.Sc.)

UNIT- IV

1. **Cell Structure and Functions :-**

Structure of prokaryotic and eukaryotic cells Intercellular organelles and their functions. comparison of Plant and animal cells. Overview of metabolic processes- catabolism and anabolism. ATP- The biological Energy currency.

Origin of life - unique properties of carbon, Chemical evolution and rise of living systems. Introduction to biomolecules, building blocks of Bio-macromolecules.

2. **Carbohydrates:-**

Conformation of monosaccharides, structure and function of Important derivatives of monosaccharide. Like glycosides-deoxy sugar myoinositol, Aminosugar, disaccharides and polysaccharides structural. Poly saccharides cellulose and chitin. Storage polysaccharides starch and glycogen. Carbohydrate of glyco-protein and glycolipids. Role of sugar in biological recognition. Blood group substances. Ascorbic Acid, Carbohydrate metabolism, Krebs Cycle, Glycolysis, Glycogenesis and Glycogenolysis, Gluconeogenesis, Pentose Phosphate Pathway.

UNIT- V

1. **Lipids :-**

Fatty acids, essential fatty acids, structure and function .of triglycerals glycerophospholipids, Sphingolipids cholesterol, bile acids, prosta-glandins lipoproteins-composition and function role in atherosclerosis. Properties of lipid aggregates micelles bilayers. Liposomes and their possible biological functions, Biological membranes, Fluid Mosaic model of membrane spectra liquid metabolism. β-Oxidation. of fatty acids.

2. **Amino acids, Peptides and Proteins :-**

Chemical & enzymatic hydrolysis of proteins to peptides, Amino Acid sequencing, secondary structure of proteins, forces responsible for holding of secondary structure., α-hetix, B-sheets super secondary structure, triple helix structure of collagen, Tertiary structure of protein folding and domain structure. Quaternary structure.

Amino Acid metabolism, degradation and biosynthesis of Amino acid. Sequence determination. Chemistry of Oxytocin and tryptophane releasing hormones (TRH)

3. Nucleic Acid :-

Purine, Pyrimidine, bases of Nucleic acid, base pairing, via H-bonding, structure of Ribo Nucleic Acid (RNA) & D.N.A. deoxy ribonucleic acid, double helix model of DNA and forces responsible for holding at chemical and Enzymatic Hydrolysis of Nucleic Acid. The Chemical bases of heredity, an overview of replication of DNA. Transcription, translation and genetic code, chemical synthesis of mono and Trinucleosides.

Book Suggested for Spectroscopy :

1. Modern Spectroscopy - J.M. Hollas Hohnwiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windowi and F.L. Ho Willey interscience.
3. NMR, NQR, ESR and mossbaure spectroscopy in Inorganic chemistry :- R.V. Parish, Ellis Harwood.
4. Physical Method in Chemistry - R.S. Drago, Saunders College.
5. Introduction to Molecular Spectroscopy - G.M. Barrow, Mcgraw Hill.
6. Basic Principle of Spectroscopy- R. Chang Mcgraw Hill.
7. Theory and Application of Uv Spectroscopy H.H. Jaffe, and M. Orchin, IBH Oxford.
8. Introduction to Photo electron spectroscopy P.K. Ghosh John Wiley.
9. Introduction to magnetic Resonance. A. Carrington and A.D. Maclachalan Harper & Row.
10. H. Kaur ,Spectroscopy , Wiley.

Books : Mathematics for chemists :

1. The Chemistry Mathematics Book : E.Steiner, Oxford University Press.
2. Mathamatics for Chemistry - Doggett and Sectcliffe longman.
3. Mathematical preparation for physical chemistry - F. Daniels Mcgrow Hill.
4. Chemical Mathematics - D.M. Hirsl- Longmann.
5. Applied Mathematics for Physical Chemistry - J.R. Barrate, Prentice Hall.
6. Basic Mathematics for Chemists Tebbutt Wiley.

Books –Biology for chemists

1. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.
2. Biochemistry, L.Stryer, W. H. Freeman.
3. Biochemistry, J. David Rawn, Neil Patterson
4. Biochemistry ,Voet & Voet John Wiley
5. Biochemistry , Jain & Jain . S. Chand .

M.Sc. CHEMISTRY SEMESTER – I
LABORATORY COURSE -I
ORGANIC CHEMISTRY

1. **Qualitative Analysis :-**

Separation, Purification and Identification of compounds of Binary Mixture. T.L.C. and Column chromatography. I.R. Spectra may be used for functional group identification of compound by suitable derivatives preparation and determination of their melting points.

2. **Organic Synthesis :-**

1. Bromination - Prepration of p-Bromo Aniline from Acetanilide.
2. Nitration - Prepration of p-Nitro Aniline from Acetanilide
3. Hofman Bromide Reaction. Prepration of Anthranilic Acid from Pthallic anhydride.
4. Aldol Condensation - Dibenzal acetone from Bazaldelyde.
5. Sandmeyer Reaction -
   1. o-Chloro Benzoic Acid from Anthranilic Acid.
   2. p- Chloro toluene from Toludine.
6. Friedal Craft Reaction - β -Benzoyl.Propionic Acid from Succinic Anhydride and Benzene.
7. Oxidation - Adipic Acid by Chromic Acid oxidation of cyclohexanol.
8. Diazotization:-
   1. Preparation of methyl orange from Sulphanilic Acid.
   2. Phenyl Azo- β. Naphthol from Aniline.
9. Preparation of Acridone from N- Phenyl anthranilic acid.
10. Grignard's reaction: Synthesis of tripheny lmethanol from Benzoic acid.

Note: Two stage preparation. Preparation of pure and crystalline compound based on any two of above principals with conformation of melting point.

3. **Quantitative Analysis:-**

1. Determination of the percentage or number of Hydroxyl group in an organic compound by Acetylation method.
1. Estimation of Amines/Phenols using Bromate - Bromide Solution / or Acetylation method.
2. Determination of equivalent- weight of carboxylic compound.
4. Estimation of carboxyl group by tritration / silver salt-method.
5. Estimation of Carbonyl group by Hydrazone method.
6. Estimation of Glycine by titration.

M.Sc. CHEMISTRY SEMESTER – I

LABORATORY COURSE - II

ANALYTICAL CHEMISTRY

SECTION- A

(Instrumentation and Computers)

1. Error Analysis & Statistical data Analysis :-

   Errors, types of errors, Minimization of Error, Statistical treatment for error analysis, standard deviation, Relative standard deviation, Linear least square. Calibration of volumetric apparatus burrettes pipette, standard flask, weight box etc.

2. Volumetric Analysis :-

   Basic Principles, determination of I_2 and saponification values of oil sample determination of DO, COD, BOD, Hardness of water samples.

3. Chromatography :-

   Separation of Cations and anions by (A) Paper Chromatography, (B) Column Chromatography.

SECTION- B

4. pH Metry / Potentiomety / Conductometry titration :-

   Determination of strength of acid etc.

5. Flame Photometry / AAS/FIA/Colorimetry :-

   Determination of Cations / anions and metal Ions eg. Na^+, K^+, Ca^{2+},$SO4^{2-}$ NO_3, Fe, Mo, Ni ,Cu, Zn etc.

6. Spectro Photometry :-

   Verification of Beer - Lambert Law. Molar Absorptivity calculation, Plotting graph to obtain λmax etc. effect of pH in aqueous coloured system. Determination of metal ions eg. Fe, Cu, Zn, Pb etc

7. Nephelometry / Turbidimetry :- Determination of chlorine, sulphate phosphate turbidity etc.

8. Application of Computer in Chemistry:- As Specified in Theory paper in section II (A).

Instruction to Practical Examiners in Chemistry Semester –I

1. The Board of Examiners; one external and one internal for each branch will meet to decide the exercises and other matter in connection with the conduct of practical examinations

S. No.	Lab. Course (branch)	Max. Marks	Duration
1.	I- Organic Chemistry	100	5 hrs.
2.	II- Analytical Chemistry	100	5 hrs.

2. The distribution of marks is as under. Marks of Ex-students are given in parentheses.

For Lab. Course –I (Organic Chemistry) :

(a) Qualitative Analysis of mixture containing two Organic compounds	30 (40) marks
(b) Preparation	10 (15) marks
(c) Estimation	20 (25) marks
(d) Viva voice	20 (20) marks
(c) Sessional	20 (-) marks
Total-	100 (100) marks

As far as possible all the exercises as laid down in the syllabus are set. The scale of marking will be determined by examiners in accordance with the nature of exercises.

For Lab. Course –II (Analytical Chemistry):

(a)Two practical exercise (one from each section)	60 (80) marks
(at least one of these will be based on instrumental analysis)	
(b) Viva voice	20 (20) marks
(c) Sessional	20 (-) marks
Total-	100 (100) marks

As far as possible all the exercises as laid down in the syllabus are set. The scale of marking will be determined by examiners in accordance with the nature of exercises.

Sessional marks will be awarded by External Examiner in consultation with the internal Examiner

Bilaspur University Bilaspur

Syllabus

Chemistry

Group- B

M.Sc.

Semester- II

2016-17

M.Sc. CHEMISTRY
SEMESTER – II
Paper –I
INORGANIC CHEMISTRY

Max. M : 80, Min. M:29

Teaching hrs- 60 hrs
Seminar hrs- 08 hrs

Note: - Two questions will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- 1

Metal Ligand Equilibria in solution:-

Step wise & overall formation constants and their interaction, trends in step wise formation constants, factors affecting the stability of Metal Complexes with reference to nature of metal ion and ligand.

UNIT- 2

Reaction mechanism of transition metal complexes:-

Energy profile of a reaction, reactivity of metal complexes, Inert and Labile complexes. Kinetic application of valence bond & crystal field theories. Kinetics of octahedral substitution, acid hydrolysis , factors affecting acid hydrolysis. Base hydrolysis, Anation reactions, Reactions without metal ligand bond cleavage, substitution reactions in square planar complexes. The trans effect.

UNIT- 3

Metal π -Complexes.

(A) Mechanism of the substitution reaction, Redox reactions, Electron transfer reactions, mechanism of one electron transfer reaction.

(B) Metal Clusters- Higher boranes ,carboranes, metalloboranes and metallocarboranes, Metal carbonyl.

UNIT- 4

(A) Metal Carbonyls, Structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls.

(B) Nitrosyl :- Preparation, bonding, structure & important reactions of transition metal nitrosyl, dinitrogen complexes, tertiary phosphine as ligand.

UNIT- 5

Isopoly and Heteropoly Acid & salt.

Isopoly acids of transition metals Mo, W,V, Nb , Ta.

Heteropoly acids and salt of Mo, W, Structure of heteropoly acids

Books Suggested :-

1. Advanced Inorganic chemistry :- F.A. Cotton and Wilkinson : John Wiley.
2. Inorganic Chemistry : J.E. Huhey, Harpes & Row
3. Chemistry of the elements: N. N. Greenwood & A Earnshow Pergamon.
4. Inorganic Electronic Spectroscopy – A..B.P. Lever, Elsevier

5. Magnetochemistry - R.L. Carlin , Springer Verlag.
6. Comprehensive Co-ordination Chemistry
G. Wilkinson, R.D. Gillars and J.A. McCleverty Pergamon.
7. Chemistry Applications of Group Theory - F.A. Cotton.
8. Group Theory :- Bhattacharya.

M.Sc. CHEMISTRY
SEMESTER – II
PAPER - II
ORGANIC CHEMISTRY
REACTION MECHANISM

Max. M : 80, Min. M:29

Teaching hrs- 60 hrs
Seminar hrs- 08 hrs

Note: - Two question will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- I

Electrophilic substitution reactions :-

(a) Aliphatic electrophilic substitution :- Biomoleculear mechanism : SE^2, SE^1, and SE_i mechanism, electrophilic substitution accompanied by double bond shifts, effect of substrates, leaving group and the solvent polarity on the reactivity.

(b) **Aromatic electrophilic substitution**

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring system. Quantitative treatment of reactivity in susbstrates and electrophiles. Diazonium coupling, Gattermann Koch reaction, Vilsmeir reaction.

UNIT- II

Nucleophilic Substitution reactions :-

(a) Aliphatic nucleophilic substitution : The S_N2, S_N1, mixed S_N^1 and S_N^2 and SET mechanism. The neighbourring group mechanism, neighbouring group participation by π and σ bonds. The SNi mechanism. Nucleophilic substitution at an allylic aliphatic trigonal and at a vinylic carbon . Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile.

(b) Aromatic Nucleophilic substitution : The S_NAr, S_N^1, benzyne and S_{RN}^1 mechanisms, Reactivity-effect of substrate structure. Leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangement.

UNIT- III

Free Radical reactions

Types of free radical reactions, Free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance.

Reactivity for aliphatic and aromatic substrates at a bridge head. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction. Free radical rearrangement, Hunsdiecker reaction.

UNIT- IV

(a) Addition to Carbon-Carbon Multiple Bonds

Mechanism and stereo chemical aspects of addition reactions involving electrophiles, Nucleophiles and Free radicals, regio and chemoselectivity, Orientation and reactivity, Addition to cyclopropane ring. Hydrogenation of double and triple bonds. Hydrogenation of Aromatic rings. Hydroborations Michael reaction, epoxidation.

(b) Addition to Carbon-Hetero Multiple bonds :

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters nitriles. Addition of Grignard's reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, mechanism of condensation reactions involving enolates - Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, Hydrolysis of ester and amides, Ammonolysis of esters.

UNIT- V

Elimination reactions :

The E_2, E_1 and E_{1cB} mechanism and their spectrum, orientation of double bond. Reactivity- effects of substrate structures, attacking base, the leaving group and the medium.

Books Suggested.

1. Advanced Organic Chemistry - Reaction Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry - F.A. Carey and R.K. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry Peter Sykes- longman.
4. Structure and Mechanism in organic chemistry - C.K. Ingold, Cornell University Press.
5. Organic Chemistry - R.T. Morrison and R.N. Boyed ,Prentice - Hall.
6. Modern Organic Reactions H.O. House, Benzamic.
7. Principles of Organic Synthesis - R.P.C. Norman and J.M. Coxon, Blackie Academic and Professional.
8. Reaction Mechanism in Organic Chemistry - S.M. Mukherji and S.P. Singh Macmillan

MSc II-SEMESTER, CHEMISTRY (2016 - 17)

PAPER - III

PHYSICAL CHEMISTRY

(KINETICS & ENERGETICS)

Max. M : 80, Min. M:29

Teaching hrs- 60
Seminar hrs- 08

Note: - Two question will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- I

THERMODYNAMICS:

Classical Thermodynamics: Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties, partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept of fugacity and determination of fugacity. Non-ideal systems : Excess functions for non-ideal solutions. Activity, Activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions, determination of activity and activity coefficients, ionic strength. Application of phase rule to three component systems, second order phase transitions.

UNIT- II

(a) Statistical Thermodynamics:

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition functions - translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition function, application of partition function. Heat capacity behavior of solids - chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and application to metal. Bose-Einstein statistics - distribution law and application to helium.

(b)Non Equilibrium Thermodynamics

Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g. heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

UNIT- III

ELECTROCHEMISTRY :

Electrochemistry of solutions, Debye-Huckel-Onsager treatment and its extension, ion solvent interactions, Debye-Huckel Jerum mode. Thermodynamics of electrified interface equations, derivations of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. Guoy-Chapman, Stern, Graham-Devanthan - Mottwatts, Tobin.

Bockris, Devanathan models. Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot. Quantum aspects of charge transfer at electrodes-solution interfaces, quantization of charge transfer, tunneling. Semiconductor interfaces - theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Effect of light a semi conductor solution interfaces.

UNIT- IV

Electrocatalysis - influence of various parameters, Hydrogen electrode. Bio-electrochemistry, threshold membrane phenomena, Nernst-Plank equation. Hodges-Huxley equation, core conductor models, electrocardiograph. Polarography theory, Ilkovic equation, half wave potential and its significance, Introduction to corrosion, homogenous theory, forms of corrosion monitoring and prevention methods.

UNIT- V

(a) ELECTRON DIFFRACTION-

Scattering intensity vs. scattering angle. Wierl equation, measurement technique, Elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surface.

(c) NEUTRON DIFFERACTION-

Scattering of neutron by solid and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

Book Suggested

1. Physical Chemistry - P.W. Atkins, ELBS
2. Introduction to Quantum Chemistry - A.K.Chandra, Tata McGraw Hill
3. Quantum Chemistry - Ira N.Levine, Prentice Hall
4. Coulson's Valence - R. McWeeny, ELBS
5. Chemical Kientics - K.J. Laidler, McGraw Hill
6. Kinetics and mechanism of chemical transformation - J.Rajaraman and J.Kuriacose; McMillan.
7. Micelles, Theoretical and Applied Aspects - V. Moroi, Plenum.
8. Modern Electrochemistry Vol.I and II - J.O.M. Bockris and A.K.N.Reddy, Plenum.
9. Introduction of Polymer Science - V.R.Gowarikar, N.V.Vishwanathan and J.Sridhar Wiley Easter

M. Sc. CHEMISTRY SEMESTER – II

PAPER –IV

SPECTROSCOPY, DIFFRACTION METHODS & COMPUTER FOR CHEMISTS

Max. M : 80, Min. M:29

Teaching hrs- 60 hrs
Seminar hrs- 08 hrs

Note: - Two questions will be asked from each Unit and student will have the choice to attempt any one question from each unit.

UNIT- I

Electronic Spectroscopy :-

A. Atomic Spectroscopy :- Energy of Atomic orbitals, Vector Representation of momenta & vector coupling, spectra of Hydrogen atom , alkali metal atom.

B. Molecular Spectroscopy :- Energy levels, Molecular orbitals, vibration transition, vibrational progression and geometry of the excited states, Franck-Condon principle, Electronic spectra of polyatomic, molecules, Emission Spectra.

C. Photo Electronic Spectroscopy :- Basic principles, Photo-electic effect Ionisation process, Photo Electron Spectra of simple molecules, E.S.C.A., Chemical Information of E.S.C.A., Auger Electron Spectroscopy-basic idea.

UNIT- II

Magnetic Resonance Spectroscopy :-

A). Nuclear Magnetic Resonance Spectroscopy :- Nuclear Spin, Nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors Influencing chemical shift, deshielding, spin-spin interaction. Factors Influencing coupling constant "J", classification (ABx, AMx, ABC, A_2B_2 etc), spin decoupling basic ideas about instruments.

B. Electron Spin Resonance Spectroscopy :- Basic principle, Zero field splitting and orbital energy degeneracy, factors affecting the 'g' value, isotopic and anisotopic hyperfine coupling constant. Spin densities and Applications of ESR

C. Nuclear Quadrupole Resonance Spectroscopy quadrupole nuclear, quadrupole moment electric field gradients, coupling constant splittings, Applications.

D. Photoacoustic Spectroscopy :- Basic principle of photoacoustic spectroscopy (PAS), PAS-gases and condensed-systems, chemical & surface application.

UNIT- III

X-ray Diffraction :-

Bragg's condition, Miller indices, Laue-method, Bragg's method, Debye-Scherrer method of X-ray structural analysis of crystals. Index- Reflections identification of unit cell from systematic absences in diffraction pattern structure of simple lattices and X-Ray Intensities structure factor and its relation to intensity and electron density. Phase problem. Description of the procedure for an X-Ray structure analysis. Absolute configuration of molecules.

COMPUTER FOR CHEMISTS

UNIT- IV

Introduction to Computer and Computer Programming in "C"

Computer Fundamental ;- Introduction to Computer organisation. Operating System, DOS, Introduction to UNIX and Window. Computer Languages Principle of programming Algorithm and flow charts.

Programming in C :- Structure of a C Programming, constants, variables, operators and Expressions, data Input & output, decision making, branching and looping statements arrays, well defined functions pointes structure and unions, Format statement. Termination statements. Branching statements such as IF of GO TO statement. LOGICAL variables. Double precision variables. Subscripted variables and DIMENSION. DO statement. FUNCTION and SUBROUTINE. COMMON and DATA statements.

UNIT- V

Programming in Chemistry and use of Computer Programmes.

1. Development of small computer codes Involving simple formulae in Chemistry such as Vander waals Equation, pH Titrations, Kinetic. Radioactive Decays. Evaluation of Lattice Energy and Ionic radie secular equation (within Huckel Theory), Elementry structural features, such as, bond lenths, bond Angle, dihedral angles etc. Of molecules extracted from a database.
2. Introduction and use of computer package MS-Word and Excel. Preparation of graphs and Charts.

Book Suggested for Spectroscopy

1. Modern Spectroscopy - J.M. Hollas Hohnwiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windowi and F.L. Ho Willey interscience.
3. NMR, NQR, ESR and mossbaure spectroscopy in Inorganic chemistry :- R.V. Parish, Ellis Harwood.
4. Physical Method in Chemistry - R.S. Drago, Saunders College.
5. Introduction to Molecular Spectroscopy - G.M. Barrow, Mcgraw Hill.
6. Basic Principle of Spectroscopy- R. Chang Mcgraw Hill.
7. Theory and Application of UV Spectroscopy H.H. Jaffe, and M. Orchin, IBH Oxford.
8. Introduction to Photo electron spectroscopy P.K. Ghosh John Wiley.
9. Introduction to magnetic Resonance. A. Carrington and A.D. Maclachalan Harper & Row.
10. Spectroscopy by Kalsi

Books suggested for Computers

1. Computer and Common Sense :- R. Hunt and J. Shelley Prentice Hall.
2. Computational Chemistry A.C. Norris.
3. Micro Computer Quantam Mechaniscs. J.P. Kilingbeck. Adam Hilger.
4. Computer Programming in fortran IV V. Rajaraman, Prentice Hall.
5. An Introduction to Digital Computer Design, V.Rajaraman and T. Radha Krishanan Prentice Hall.

M.Sc. CHEMISTRY SEMESTER – II

LABORATORY – COURSE I

INORGANIC-CHEMISTRY

Note- Student are accepted to complete all exercises.

1. Qualitative analysis of mixture containing eight radical including some less common metal ions among the following by common method (Preferably semi-micro method)

Group-A

Basic Radicals : - {Ag, Pb, Hg, Cu, Cd, Bi, As, Sb, Sn, Fe, Al, Cr, Zn, Mn, co, Ni, Ba, Sr, Ca, Mg, Na, K, NH_4,}

Acid Radicals :- {CO_3, SO_4, SO_3, NO_3, F, Cl, Br, I, NO_2, BO_3, C_2O_4, PO_4}

Group– B

Basic Radicals : - {Ce, Th, Zr, W, Te, Ti, Mo, U, V, Be, Li, Au, Pt.}

Acid Radicals :-{SiO_4, Thiosulphate, Ferrocynide, Ferricyanide, Chromate, Arsenite , Arsenate, Permanganate }

Note – The mixture to be analysed by the students must contain at least one basic and one acid radicals from Group B.

2. **Quantitative Analysis :-**

Involving two of the following in ores, alloys or mixture in solution- one by volumetric and other by gravimetric method Ag, Cu, Fe, Cr, Mn, Ni, Zn, Ca, Mg, Chloride, Sulphate.

3. **Estimation of :-**

(A) Phosphoric acid in Commercial ortho phosphoric acid.

(B) Boric Acid in Borax.

(C) Ammonium Ion in Ammonium Salt.

(D) MnO_2 in pyrolusite

(E) Available Chlorine in bleaching powder.

(F) H_2O_2 in commercial sample.

Students are expected to perform at least three exercises

From above during laboratory work.

4. Preparation of selected Inorganic compounds and study of their properties by various method including IR, Electronic Spectra, Mossbaur, ESR, Spectra+ Magnetic susceptibility etc.

(i) $V0(acac)_2$

(ii) cis K $[Cr(C_2O_4)_2(H_2O)_2]$,

trans K $[Cr(C_2O_4)_2(H_2O)_2]..2H_2O$

(iii) $[Co(NH_3)_6]Cl_3$

(iv) Na $[Cr(NH_3)_2(SCN)_4]$

(v) $Mn(acac)_3$

(vi) $K_3[Fe(C_2O_4)_3]$

(vii) Prussian Blue Turnbull's Blue.

(viii) $[Co(NH_3)_6]$ $[Co(NO_2)_6]$

(ix) Hg $[Co(SCN)_4]$

(x) $[Ni(NH_3)_4]Cl_2$ $[Ni(NH_3)_4]Cl_2$

(xi) Ni $(DMG)_2$(xii)$[Cu(NH_3)_4]SO_4$

(xii) $K_3[Cr(C_2O_4)_3].3H_2O$

(xiii) $[Cu(NH_3)_4]SO_4$

M.Sc. CHEMISTRY SEMESTER – II

LABORATORY COURSE- II

PHYSICAL CHEMISTRY

1. Adsorption :-

i. Verification of Freundlich's Adsorption Isotherm.

ii. To study surface tension – concentration relationship for solutions (Gibbs equation).

2. Phase Equilibria:

i. Determination of congruent composition and temperature of binary system e.g. diphenylamine – benzophenone system.

ii. Determination of glass transition temperature of given salt e. g. $CaCl_2$ conductometrically.

iii. To construct the phase diagram for three component system e. g. chloroform, acetic acid and water.

3. Chemical Kinetics

i. hydrolysis of an ester/ ionic reactions.

ii. Determination of the velocity constant of hydrolysis of an ester. Determination of effect of (a)change of temperatures, (b)change of concentration of reactants and catalyst and(c)ionic strength of the media on the velocity constant of media.

iii. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide

iv. Determination of the primary salt effect on the kinetics of ionic reaction and testing of the Bronsted relationship (iodide ions oxidized by persulphate ion).

4. Conductometry

i. Determination of solubility of sparingly soluble salt (eg, $PbSO_4$, $BaSO_4$) Conductometrically.

ii. Determination of the strength of strong and weak acids in a given mixture conductometrically.

iii. Determination of dissociation constant of weak electrolyte by conductometer.

iv. Determination of velocity constant, Order of reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide.

5. pH Metry/Potentiometry

1. Determination of the strength of strong and weak acid in a given mixture using pH meter/potentiometer.
2. Determination of dissociation constant of weak acid by pH meter.
3. Determination of concentration of acid in given buffer solution by pH meter.
4. Determination of strength of halides in a mixture potentiometrically.
5. Determination of the valency of mercurous ions potentiometrically.
6. Determination of the strength of strong acid, weak acids in a given mixture using a potentiometer/ pH meter.
7. Determination of temperature dependence of EMF of a cell.
8. Determination of the formation constant of silver- ammonia complex and stoichiometry of the complex potentiometrically.
9. Determination of activity and activity coefficient of electrolytes.
10. Determination of thermodynamic constant. $\Delta G, \Delta S$ and ΔH for the reaction by e.m.f. method.

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

11. Determination of the dissociation constant of monobasic / dibasic acid

6. Polarimetry:-

1. Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.
2. Enzyme kinetic – inversion of sucrose.

7. Solutions:

i. Determination of molecular weight of non-volatile and non- electrolyte/electrolytes by cryoscopy method and to determine the activity coefficient of an electrolyte.

ii. Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behavior that occurs with a strong electrolyte.

Instructions to Practical Examiners in Chemistry
Semester - II

1. The Board of Examiners - one external and one internal for each branch will meet to decide the exercises and other matter in connection with the conduct of practical examinations.

S.No.	Branch	Marks	Duration
(i). Lab Course-I	Inorganic Chemistry	100	10 hours
(ii) Lab Course-II	Physical Chemistry	100	05 hours

2. Sessional marks will be awarded by External Examiner in consultation with the Internal Examiner.
3. 3.The distribution of marks is as under. Marks for Ex-students are given in parentheses.

For Lab. Course –I (Inorganic Chemistry):

(a) Qualitative analysis of mixture containing not more than 8 radicals by semi-micro method only. 32 (42) marks

(b) Quantitative analysis (involving separation) of a solution containing 2 metals, one of these is to be estimated gravimetrically and the other volumetrically. 18 (23) marks

(c) Preparation 10 (15) marks

(d) Viva voce and manipulation 20 (20) marks

(e) Sessional 20 (--) marks

Total 100 (100) marks

For Lab. Course –II (Physical Chemistry):

(a) One practical exercise 60 (80) marks

(b) Viva voice and manipulation 20 (20) marks

(c) Sessional 20 (....) marks

Total 100 (100) marks

As far as possible all the exercises as laid down in the syllabus are set. The scale of marking will be determined by examiners in accordance with the nature of exercises.