PATNA UNIVERSITY

B. Sc., Chemistry Honours & Subsidiary Syllabus
Part I, II & III
(w. e. f. 2015)

Department of Chemistry
Patna University
Patna – 800 005

Patna University

Letter No. Acad/- 3225 Dated 6·/0·/5-

To
All the Heads of the University Departments
Patna University, Patna

Sub: - Revision of Undergraduate and Post Graduate Syllabus / Courses of Studies.

Sir

In continuation of this office letter no. Acad / 2547 dated 18.06.2015 I am directed to inform you that the Heads of the respective University Departments are authorized to conduct the meeting of the respective Boards of Courses of Studies.

The resolution taken by the respective Boards of Courses and Studies be sent to the respective Deans of the Faculties who will convene the meeting of the Faculty for further necessary action.

This may kindly be treated as most urgent.

Yours faithfully

6.10.15

Deputy Registrar
Patna University, Patna

5/9/15

Ph. : (0612) 2672214

DEPARTMENT OF CHEMISTRY

PATNA UNIVERSITY, PATNA - 800 005

Ref.: CH-299

Date: 16/10/2015

To,

The Dean,
Faculty of Science,
Patna University, Patna

Sub: The resolution taken by the Board of Courses and Studies

Ref: P.U. letter no. Acad/-3225 dated 06.10.2015

Sir,

I am sending herewith the resolution taken in the meeting of the Board of Courses and studies of the Department of Chemistry, Patna University, Patna by the Board of Courses and studies of the Department of Chemistry, Patna University, Patna for further necessary action.

Yours faithfully,

Ashis Kumar Ghosh 16/10/205

(Dr. Ashis Kumar Ghosh)
Head of the Department of Chemistry,
Patna University, Patna

Enclosure:

1. Minutes cum Resolution approval letter
2. Revised B.Sc. & M.Sc. Syllabus
3. P.U. letter no. Acad/3333 dated 15.10.2015
4. P.U. letter no. Acad/3335 dated 15.10.2015

Ashis Kumar Ghosh 16/10/2015

(Dr. Ashis Kumar Ghosh)

OFFICE OF THE
DEAN OF THE FACULTY OF SCIENCE
PATNA UNIVERSITY,
PATNA - 800 005 (INDIA)

Ref. : D.F-SC.290 Date : 4.8.2015

NOTIFICATION

The Board of Courses and Studies for the Subject of Chemistry is constituted with the following members as per decision of the meeting of the Faculty of Science held on 03/08/2015 in Department of Chemistry:

Chairman:

Prof (Dr.) A.K. Ghosh, H.O.D. Chemistry, P.U. - ex officio

External Experts

1. Prof (Dr.) A. K. Bakhshi , FNA.
Sir Shankar Lal Professor of Chemistry, University of Delhi.
Former Executive Director, Tertiary Education Commission Mauritius
Former VC, UPRTOU, Allahabad.
Mob: +91 88266 76577

2. Prof (Dr.) C. Bhakta, Former H.O.D. Patna Science College. P.U.
Mob: +91 90065 06877

Teachers of the subjects in the University

1. Dr. Ramjatan Sinha, Prof. & Former PG H.O.D, Chemistry, Patna University.
2. Dr. R. K. Prasad, UG H.O.D. Patna Science College.
3. Dr. K. R. R. P. Sinha, Prof. of Chemistry, Patna University.
4. Dr. D. N. Thakur, Associate Prof Chemistry, Patna University.
5. Prof. M. B. Ojha H.O.D. Chemistry, B.N, College, Patna.
6. Dr. (Mrs.) Basabi Mahapatra, H.O.D. Chemistry, M.M. College, Patna.
7. Dr. (Mrs.) Madhu Rani Sinha, H.O.D. Patna Women's College.

copy to
Chairman: Prof A.K. Ghosh.
HOD, Chemistry, P.U.

Ramjatan Sinha
Dean, Faculty of Science, P.U.

Syllabus Approval Committee

Department of Chemistry
Patna University

The following are the members for the Board of Courses of Studies for the Subject of Chemistry.

Chairman:

Prof (Dr.) A.K. Ghosh, H.O.D. Chemistry, P.U. - ex officio

Signature

Date: -

External Experts

1. Prof (Dr.) A. K. Bakhshi, FNA. Sc.
   Sir Shankar Lal Professor of Chemistry, DU

Signature

Date: -

2. Prof (Dr.) C. Bhakta, Former H.O.D. Patna Science College. P.U.

Signature

Date: - 15/10/2015

Teachers of the subjects in the University

1. Prof. (Dr.) Ramjatan Sinha, Dean Faculty of Science & Former PG H.O.D, Chemistry, Patna University.

Signature

Date: - 15 10 2015

2. Prof. (Dr.) R. K. Prasad, UG H.O.D. Chemistry, Patna Science College, P.U.

Date: -

Signature 15/10/2015

3. Prof. (Dr.) K. R. R. P. Singh, Prof. of Chemistry, P.U.

Date: - 15/10/15

Signature 15/10/15

4. Dr. D. N. Thakur, Associate Prof Chemistry, P.U.

15/10/15

Date: -

Signature

5. Prof. M. B. Ojha H.O.D. Chemistry, B.N. College, Patna.

15.10.15

Date: -

Signature

6. Prof. (Dr.) Mrs. Basabi Mahapatra, H.O.D. Chemistry, M.M. College, Patna.

Date: - 15.10.15

Signature

7. Dr. (Mrs.) Madhu Rani Sinha, H.O.D. Patna Women's College.

15.10.15

Date: - 15.10.15

Signature

B. Sc. Chemistry (H)
1st Year
Paper 1A

Time 3 Hours **Full Marks: 50**

Physical Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Gaseous States — 8 Hrs

Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state.

Critical Phenomena : PV isotherms of real gases, continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.

Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquification of gases (based on Joule-Thomson effect).

II Liquid State — 6 Hrs

Intermolecular forces, structure of liquids (a qualitative description).

Structural differences between solids, liquids and gases.

Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholestric phases. Thermography and seven segment cell.

III Solid State — 11 Hrs

Definition of space lattice, unit cell.

Laws of crystallography – (i) Law of constancy of interfacial angles (ii) Law of rationality of indices (iii) Law of symmetry. Symmetry elements in crystals.

X-ray diffraction by crystals. Derivation of Bragg equation. Determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

IV Chemical Kinetics and Catalysis — 13 Hrs

Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction – concentration, temperature, pressure, solvent, light, catalyst. Concentration dependence of rates, mathematical characteristics of simple chemical reactions – zero order, first order, second order, pseudo order, half life and mean life. Determination of the order of reaction – differential method, method of integration, method of half life period and isolation method.

Radioactive decay as a first order phenomenon.

Experimental methods of chemical kinetics: conductometric, potentiometric, optical methods, polarimetry and spectrophotometer.

Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy,

Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Catalysis, characteristics of catalysed reactions, classification of catalysis, miscellaneous examples.

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V Colligative properties of dilute solutions

Ideal and Non ideal solutions. The thermodynamics derivations of Rault's law relative lowering vapour pressure, osmotic pressure, elevation in boiling point (Ebullioscopy), depression in freezing point (Cryoscopy).

Determination of molecular mass of a solute by: (i) Berkeley-Hartley's method (π); (ii) Beckmann's method (ΔT_f) and (iii) Landsberger's method (ΔT_b), abnormal molecular mass, degree of dissociation and association of solutes, Numerical problems.

SUGGESTED BOOKS:

1. Physical Chemistry, 7th Edition, P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, OxfordUniv. Press, 2000.
3. Physcial Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low-priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition, 1999.
5. Text Book of Physical Chemistry, S.Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition, B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987
7. Text Book of Physical Chemistry, P. L. Soni., S. Chand & Co., 1993.
8. Physcial Chemistry Alberty, R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry, G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition, Gibert W. Castellan, Narora Publishing House, 1985.
11. Text Book of Polymer Science, Billmeyer, Dr. F. W. John Wiley & Sons, 1984.
12. Basic Physical Chemistry, Walter J. Moore, Prentice Hall, 1972.

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B. Sc. Chemistry (H)

1st Year

Paper 1B

Time 3 Hours **Full Marks: 50**

Inorganic Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Atomic Structure — 6 Hrs

Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrodinger wave equation, significance of ψ and ψ^2, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements, effective nuclear charge

II Periodic Properties — 5 Hrs

Atomic and ionic radii, ionization energy, electron affinity and electronegativity – definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

III Chemical Bonding — 20 Hrs

(A) Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory to NH_3, H_3O^+, SF_4, ClF_3, ICl_2^- and H_2O. MO theory, homonuclear and heteronuclear (CO and NO) diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

(B) Ionic Solids – Ionic structures, radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule. Metallic bond-free electron, valence bond and band theories.

(C) Weak Interactions – Hydrogen bonding, van der Waals forces

IV s-Block Elements — 6 Hrs

Comparative study, diagonal relationships, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.

V p-Block Elements — 20 Hrs

Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of groups 13-16, hydrides of boron-diborane

V Environmetal Chemistry **3 Hrs**

Ozone Depletion in stratosphere, Causes and remedies. Green house effects and its consequences as acid rain, photo-chemistry, smog.

and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides.

VI Chemistry of Noble Gases **3 Hrs**

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

SUGGESTED BOOKS:

1. Advanced Inorganic Chemistry, 6th Edition F. A. Cotton, G. Wilkinson, C. A.
2. Murillo and M. Bochmann-John Wiley & Sons, 1999.
3. Concise Inorganic Chemistry, 5th Edition J. D. Lee, Blackwell Science, 2001.
4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000
5. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
6. Environmental Chemistry A. K. De, Wiley Eastern Ltd., 1999.
7. Nuclear and Radiation Chemistry Sharma B. K, Goel Publishing House, 1987.
8. Modern Inorganic Chemistry W. L. Jolly, McGraw Hill Co.
9. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
10. Inorganic Chemistry, 3rd Edition (ISE) A. G Sharpe, Addison Wesley, 1989.
11. Basic Inorganic Chemistry, 3rd Edition F. A. Cotton, G. Wilkinson, P. L. Gaus-John Wiley & Sons, 1995.
12. Essential Chemistry, International Edition R. Chang, McGraw Hill Co, 1996.
13. University Chemistry, 4th Edition (ISE) B. H. Mahan & R. J. Myers, Addison Wesley, 1989.
14. Essential Trends in Inorganic Chemistry C. M. P. Mingos, Oxford Univ Press, 1998
15. Chemistry, 3rd Edition P. Atkins &L.Jones, W. H. Freeman & Company, 1997.
16. Modern Chemistry, 4th Edition D. W. Oxicby, H. P. Gills & N. H. Nachtrieb, Saunders College Publishing, 1998.
17. Fundamental Concepts of applied Chemistry, Jayashree Ghosh, S Chand Publications.
18. Industrial Chemistry, B. K. Sharma, Goel Publishing House

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B. Sc. Chemistry (H)
1st Year
Paper 1C

Time 3 Hours **Full Marks: 50**

Organic Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Structure and Bonding — 5 Hrs

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, van der Waals interactions, inclusion compounds, clatherates, charge transfer complexes, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.

II Mechanism of Organic Reactions — 8 Hrs

Curved arrow notation, drawing electron movements with arrows, half-headed and double-headed arrows, homolytic and heterolytic bond breaking. Types of reagents – electrophiles and nucleophiles. Types of organic reactions. Energy considerations.

Reactive intermediates — carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species.

Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

III Stereochemistry of Organic Compounds — 12 Hrs

Concept of isomerism. Types of isomerism.

Optical isomerism — elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization.

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

Geometric isomerism — determination of configuration of geometric isomers. E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism — conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae.

Difference between configuration and conformation.

IV Alkanes and Cycloalkanes — 7 Hrs

IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atoms in alkanes. Isomerism in alkanes, sources, methods of formation (with

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special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties and chemical reactions of alkanes.

Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Cycloalkanes — nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. The case of cyclopropane ring: banana bonds.

V Alkenes, Cycloalkenes, Dienes and Alkynes — 12 Hrs

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.

Chemical reactions of alkenes — mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration–oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$ Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene.

Methods of formation, conformation and chemical reactions of cycloalkenes.

Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes. Structure of allenes and butadiene, methods of formation, polymerization. Chemical reactions — 1,2 and 1,4 additions, Diels-Alder reaction.

Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization.

VI Arenes and Aromaticity — 8 Hrs

Nomenclature of benzene derivatives. The aryl group. Aromatic nucleus and side chain. Structure of benzene: molecular formula and Kekule structure. Stability and carbon-carbon bond lengths of benzene, resonance structure, MO picture.

Aromaticity: the Huckel rule, aromatic ions.

Aromatic electrophilic substitution — general pattern of the mechanism, role of σ- and π-complexes. Mechansim of nitration, halogenation, sulphonation, mercuration and Friedel-Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives. Birch reduction.

Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl.

VII Alkyl and Aryl Halides — 8 Hrs

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions. Mechanisms of nucleophilic substitution reactions of alkyl halides, S_N2 and S_N1 reactions with energy profile diagrams.

Polyhalogen compounds: chloroform, carbon tetrachloride.

Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions.

Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides. Synthesis and uses of DDT and BHC.

SUGGESTED BOOKS:

1. Organic Chemistry, Paula YurkanisBruice, Prentice Hall, 2005.
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum, 1990.
3. Organic Chemistry, Vol I & II, I.L. Finar, ELBS, 1986, 1991, 2005
4. Organic Chemistry, R.T. Morrison and R. N. Boyd, Prentice Hall, 1991
5. Organic Chemistry, Maitland Jones, Jr., W. W. Norton & Company
6. Advanced Organic Chemistry, O.S. Bahl and A. Bahl., S. Chand & Co. 1995
7. Advanced Organic Chemistry, J. March, John Wiley & Sons, 2008.
8. Understanding Organic Reaction Mechanisms, A. Jacobs, CambridgeUniv Press, 1998.
9. Organic Chemistry, M. K. Jain, Nagin& Co., 1987
10. A Guide to Mechanism in Organic Chemistry, P.Sykes, Orient Longman, 2005.
11. Organic Spectroscopy, V. R. Dani, Tata McGraw Hill, 1998.
12. Organic Spectroscopy, W.Kemp, ELBS IV Edition, 1998.
13. Synthetic Drugs, G. R. Chatwaal, Himalaya Publications, 2000.
14. Steriochemistry of Organic Compounds, Ernest L. Eliel, Samuel H. Wilen, Wiley India Edition, 1994.

B. Sc Chemistry (Hons)
Paper II
Lab Course

Time: 6 Hours **Full Marks: - 50**

Inorganic Chemistry

Semimicro Analysis – cation analysis, separation and identification of ions from Groups I, II, III, IV, V of analytical group.

Calibration of fractional weights, pipettes and burettes. Preparation of standard solutions. Dilution- 0.1 M to 0.001 M solutions.

Quantitative Analysis

Volumetric Analysis

(a) Determination of acetic acid in commercial vinegar using NaOH
(b) Determination of alkali content – antacid tablet using HCl.
(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
(d) Estimation of hardness of water by EDTA.
(e) Estimation of ferrous and ferric by dichromate method.
(f) Estimation of copper using thiosulphate.

Gravimetric Analysis

Analysis of Cu as CuSCN and Ni as Ni (dimethylgloxime).

Synthesis and Analysis

(a) Preparation of sodium trioxalato ferrate (III), $Na_3[Fe(C_2O_4)_3]$ and determination of its composition by permaganometry.
(b) Preparation of Ni-DMG complex, $[Ni(DMG)_2]$.
(c) Preparation of copper tetraammine complex, $[Cu(NH_3)_4]SO_4$.
(d) Preparation of *cis*- and *trans*- bisoxalato diaqua chromate(III) ion.

Instrumentation

Colorimetry

(a) Job's method (b) Mole-ratio method
Adulteration – Food stuffs.
Effluent analysis, water analysis.

Solvent Extraction

Separation and estimation of Mg(II) and Fe(II))

Ion Exchange Method

Separation and estimation of Mg(II) and Zn(II).

Books Suggested (Laboratory Courses)

1. Vogel's Qualitative Inorganic Analysis, revised, Svehla, Orient Longman.
2. Vogel's Textbook of Quantitative Inorganic Analysis (revised), J. Bassett, R. C. Denney, G. H. Jeffery and J Mendham, ELBS.
3. Standard Methods of Chemical Analysis, W. W. Scott, The Technical Press.
4. Experimental Inorganic Chemistry, W. G. Palmer, Cambridge.
5. Handbook of Preparative Inorganic Chemistry, Vol I&II, Brauer, Academic Press.
6. Inorganic Synthesis, McGraw Hill.

B. Sc. Chemistry (H)
2nd Year
Paper II A

Time 3 Hours **Full Marks: 50**

Physical Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Thermodynamics – I — 12 Hrs

Definition of thermodynamic terms: system, surroundings etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process. Concept of heat and work.

First Law of Thermodynamics: statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law - Joule-Thomson coefficient and inversion temperature. Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry: standard state, standard enthalpy of formation- Hess's Law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.

II Thermodynamics -II — 13 Hrs

Second law of thermodynamics: need for the law, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature.

Concept of entropy: entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases.

Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions; Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change. Variation of G and A with P, V and T.

III Chemical Equilibrium — 5 Hrs

Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier's principle.

Reaction isotherm and reaction isochore – Clapeyron equation and Clausius -Clapeyron equation, applications.

IV Phase Equilibrium — 10 Hrs

Statement and meaning of the terms – phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system – water, CO_2 and S systems.

Phase equilibria of two component system – solid-liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, desilverisation of lead.

Solid solutions – compound formation with congruent melting point (Mg-Zn) and incongruent melting point, ($NaCl$-H_2O), ($FeCl_3$-H_2O) and $CuSO_4$-H_2O) system. Freezing mixtures, acetone -dry ice.

Liquid – liquid mixtures - Ideal liquid mixtures, Raoult's and Henry's law. Non-ideal system-azeotropes – HCl-H_2O and ethanol – water systems.

Partially miscible liquids – Phenol-water, trimethylamine-water, nicotine-water systems. Lower and upper consolute temperature. Effect of impurity on consolute temperature.

Immiscible liquids, steam distillation.

Nernst distribution law – thermodynamic derivation, applications.

V Electrochemistry – I

10 Hrs

Electrical transport -conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution.

Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations. Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf method and moving boundary method.

Applications of conductivity measurements: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

VI Electrochemistry - II

10 Hrs

Types of reversible electrodes – gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode-reference electrodes- standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells – reversible and irreversible cells, conventional representation of electrochemical cells.

EMF of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), polarization, over potential and hydrogen overvoltage.

Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods.

Buffers – mechanism of buffer action, Henderson-Hazel equation. Hydrolysis of salts.

Corrosion – types, theories and methods of combating it.

SUGGESTED BOOKS:

1. Physical Chemistry, 7th Edition, P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, OxfordUniv. Press, 2000.
3. Physcial Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low-priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition, 1999.
5. Text Book of Physical Chemistry, S.Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition, B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987
7. Text Book of Physical Chemistry, P. L. Soni., S. Chand & Co., 1993.
8. Physcial Chemistry Alberty, R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry, G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition, Gibert W. Castellan, Narora Publishing House, 1985.
11. Text Book of Polymer Science, Billmeyer, Dr. F. W. John Wiley & Sons, 1984.
12. Basic Physical Chemistry, Walter J. Moore, Prentice Hall, 1972.

B. Sc. Chemistry (H)
2nd Year
Paper II B

Time 3 Hours | Full Marks: 50

Inorganic Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Chemistry of Elements of First Transition Series — 10 Hrs

Characteristic properties of d-block elements.
Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.

II Chemistry of Elements of Second and Third Transition Series — 10 Hrs

General characteristics, comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry

III Oxidation and Reduction — 8 Hrs

Use of redox potential data – analysis of redox cycle, redox stability in water – Frost, Latimer and Pourbaix diagrams. Principles involved in the extraction of the elements.

IV Coordination Compounds — 10 Hrs

Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes

V Chemistry of Lanthanide Elements — 6 Hrs

Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

VI Chemistry of Actinides — 4 Hrs

General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides

VII Acids and Bases — 6 Hrs

Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concepts of acids and bases.

VIII Non-aqueous Solvents — 6 Hrs

Physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH_3 and liquid SO_2.

SUGGESTED BOOKS:

1. Advanced Inorganic Chemistry, 6th Edition F. A. Cotton, G. Wilkinson, C. A.
2. Murillo and M. Bochmann-John Wiley & Sons, 1999.
3. Concise Inorganic Chemistry, 5th Edition J. D. Lee, Blackwell Science, 2001.
4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000
5. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
6. Environmental Chemistry A. K. De, Wiley Eastern Ltd., 1999.
7. Nuclear and Radiation Chemistry Sharma B. K, Goel Publishing House, 1987.
8. Modern Inorganic Chemistry W. L. Jolly, McGraw Hill Co.
9. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
10. Inorganic Chemistry, 3rd Edition (ISE) A. G Sharpe, Addison Wesley, 1989.
11. Basic Inorganic Chemistry, 3rd Edition F. A. Cotton, G. Wilkinson, P. L. Gaus-John Wiley & Sons, 1995.
12. Essential Chemistry, International Edition R. Chang, McGraw Hill Co, 1996.
13. University Chemistry, 4th Edition (ISE) B. H. Mahan & R. J. Myers, Addison Wesley, 1989.
14. Essential Trends in Inorganic Chemistry C. M. P. Mingos, Oxford Univ Press, 1998
15. Chemistry, 3rd Edition P. Atkins &L.Jones, W. H. Freeman & Company, 1997.
16. Modern Chemistry, 4th Edition D. W. Oxicby, H. P. Gills & N. H. Nachtrieb, Saunders College Publishing, 1998.
17. Fundamental Concepts of applied Chemistry, Jayashree Ghosh, S Chand Publications.
18. Industrial Chemistry, B. K. Sharma, Goel Publishing House

B. Sc. Chemistry (H)
2nd Year
Paper II C

Time 3 Hours **Full Marks: 50**

Organic Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Electromagnetic Spectrum: Absorption Spectra — 10 Hrs

Ultraviolet (UV) absorption spectroscopy — absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.
Infrared (IR) absorption spectroscopy — molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds.

II Alcohols — 6 Hrs

Classification and nomenclature.
Monohydric alcohols — nomenclature, methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding. Acidic nature. Reactions of alcohols.
Dihydric alcohols — nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol-pinacolone rearrangement.
Trihydric alcohols — nomenclature and methods of formation, chemical reactions of glycerol.

III Phenols — 6 Hrs

Nomenclature, structure and bonding. Preparation of phenols, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols — electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

IV Ethers and Epoxides — 3 Hrs

Nomenclature of ethers and methods of their formation, physical properties. Chemical reactions — cleavage and autoxidation, Ziesel's method.
Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

V Aldehydes and Ketones — 14 Hrs

Nomenclature and structure of the carbonyl group. Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, synthesis of ketones from nitriles and from carboxylic acids. Physical properties.

Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Wittig reaction. Mannich reaction.

Use of acetals as protecting group. Oxidation of aldehydes, Baeyer–Villiger oxidation of ketones, Cannizzaro reaction. MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones.

An introduction to α,β unsaturated aldehydes and ketones.

VI Carboxylic Acids — 6 Hrs

Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Preparation of carboxylic acids. Reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides. Reduction of carboxylic acids. Mechanism of decarboxylation.

Methods of formation and chemical reactions of halo acids. Hydroxy acids: malic, tartaric and citric acids.

Methods of formation and chemical reactions of unsaturated monocarboxylic acids.

Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.

VII Carboxylic Acid Derivatives — 3 Hrs

Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anhydrides. Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

Preparation of carboxylic acid derivatives, chemical reactions. Mechanisms of esterification and hydrolysis (acidic and basic).

VIII Organic Compounds of Nitrogen — 12 Hrs

Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid.

Halonitroarenes: reactivity. Structure and nomenclature of amines, physical properties. Stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Gabriel-phthalimide reaction, Hofmann bromamide reaction.

Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

SUGGESTED BOOKS:

1. Organic Chemistry, Paula YurkanisBruice, Prentice Hall, 2005.
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum, 1990.
3. Organic Chemistry, Vol I & II, I.L. Finar, ELBS, 1986, 1991, 2005
4. Organic Chemistry, R.T. Morrison and R. N. Boyd, Prentice Hall, 1991
5. Organic Chemistry, Maitland Jones, Jr., W. W. Norton & Company
6. Advanced Organic Chemistry, O.S. Bahl and A. Bahl., S. Chand & Co. 1995
7. Advanced Organic Chemistry, J. March, John Wiley & Sons, 2008.
8. Understanding Organic Reaction Mechanisms, A. Jacobs, CambridgeUniv Press, 1998.
9. Organic Chemistry, M. K. Jain, Nagin& Co., 1987
10. A Guide to Mechanism in Organic Chemistry, P.Sykes, Orient Longman, 2005.
11. Organic Spectroscopy, V. R. Dani, Tata McGraw Hill, 1998.
12. Organic Spectroscopy, W.Kemp, ELBS IV Edition, 1998.
13. Synthetic Drugs, G. R. Chatwaal, Himalaya Publications, 2000.
14. Steriochemistry of Organic Compounds, Ernest L. Eliel, Samuel H. Wilen, Wiley India Edition, 1994.

15/10/15 15/10/2015 15/10/15 15/10/2015

B. Sc Chemistry (Hons)
Paper IV
Lab Course

Time: 6 Hours **Full Marks: - 50**

Organic Chemistry

Laboratory techniques

Calibration of Thermometer

80-82° (Naphthalene), 113.5-114° (Acetanilide),
132.5-133° (Urea), 100° (Distilled Water)

Determination of melting point

Naphthalene 80 -82°, Benzoic acid 121.5-122°
Urea 132.5-133°, Succinic acid 184.5-185°
Cinnamic acid 132.5-133°, Salicylic acid 157.5-158°
Acetanilide 113.5-114°, m-Dinitrobenzene 90°
p-Dichlorobenzene 52°, Aspirin 135°

Determination of boiling points

Ethanol 78°, Cyclohexane 81.4°, Toluene 110.6°, Benzene 80°

Mixed melting point determination

Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

Distillation

Simple distillation of ethanol-water mixture using water condenser
Distillation of nitrobenzene and aniline using air condenser

Crystallization

Concept of induction of crystallization
Phthalic acid from hot water (using fluted filter paper and stemless funnel)
Acetanilide from boiling water
Naphthalene from ethanol
Benzoic acid from water

Laboratory Techniques

A. Thin Layer Chromatography

Determination of R_f values and identification of organic compounds.

(a) Separation of green leaf pigments (spinach leaves may be used).

(b) Preparation and separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- and 3-one using toluene and light petroleum (40:60).

(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

B. Paper Chromatography: Ascending and Circular

Determination of R_f values and identification of organic compounds.

(a) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid. Spray reagent – ninhydrin.

(b) Separation of a mixture of D, L – alanine, glycine, and L-Leucine using n-butanol:acetic acid:water (4:1:5). Spray reagent – ninhydrin.

Steam Distillation

Naphthalene from its suspension in water

Clove oil from cloves

Separation of o-and p-nitrophenols

Column Chromatography

Separation of fluorescein and methylene blue

Separation of leaf pigments from spinach leaves

Resolution of racemic mixture of (±) mandelic acid

Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.

Synthesis of Organic Compounds

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone. Benzoylation of aniline and phenol

(b) Aliphatic electrophilic substitution
Preparation of iodoform from ethanol and acetone

(c) Aromatic electrophilic substitution
Nitration
Preparation of m-dinitrobenzene
Preparation of p-nitroacetanilide
Halogenation
Preparation of p-bromoacetanilide
Preparation of 2,4,6-tribromophenol

(d) Diazotizatoin/coupling
Preparation of methyl orange and methyl red

(e) Oxidation
Preparation of benzoic acid from toluene

(f) Reduction
Preparation of aniline from nitrobenzene
Preparation of m-nitroaniline from m-dinitrobenzene.

Stereochemical Study of Organic Compounds via Models

R and S configuration of optical isomers.
E, Z configuration of geometrical isomers.
Conformational analysis of cyclohexanes and substituted cyclohexanes.

Suggested Books:

1. Experimental Organic Chemistrty Vol I&II, P.R. Singh, D.S.Gupta and K.S. Bajpai, Tata McGraw Hill
2. Laboratory Manual in Organic Chemistry, R.K. Bansal, Wiley Eastern.
3. Vogel's Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, V. Rogers, P. W. G. Smith and A. R. Tatchell, ELBS

B. Sc. Chemistry (H)
3rd Year
Paper III A

Time 3 Hours **Full Marks: 50**

Physical Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included)

I Elementary Quantum Mechanics 20 Hrs

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect.

De Broglie hypothesis, the Heisenberg's uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box.

Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.

Molecular orbital theory, basic ideas – criteria for forming M.O from A.O, construction of M.O's by LCAO - H_2^+ ion,calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics. Hybrid orbitals – sp, sp^2, sp^3; calculation of coefficients of A.O.'s used in these hybrid orbitals.

Introduction to valence bond model of H_2, comparison of M.O. and V.B. models.

II Spectroscopy 20 Hrs

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum

Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum

Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.
Qualitative description of σ, π- and n M.O., their energy levels and the respective transitions.

III Photochemistry — 8 Hrs

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions - energy transfer processes (simple examples).

IV Physical Properties and Molecular Structure — 5 Hrs

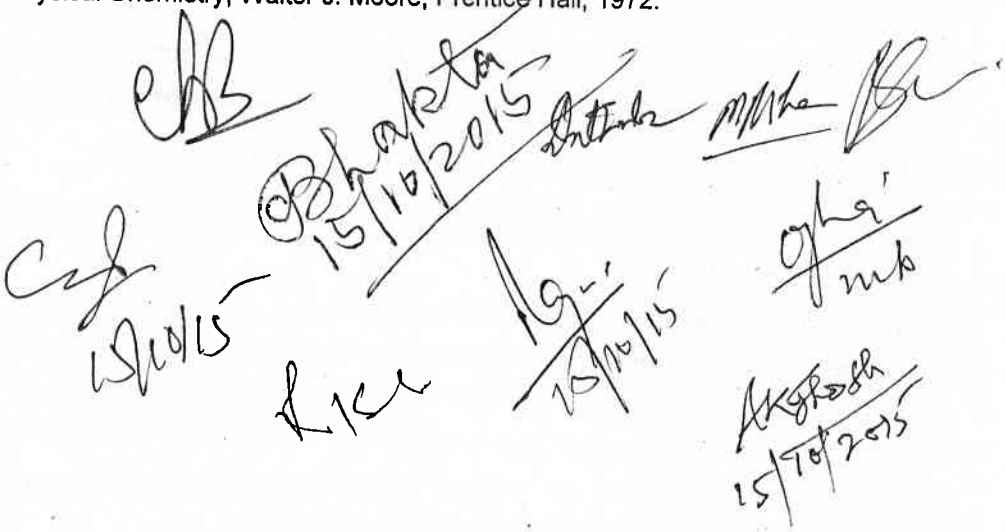
Optical activity, polarization – (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties –paramagnetism, diamagnetism and ferromagnetics.

V Solutions, Dilute Solutions and Colligative Properties — 7 Hrs

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient.
Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.
Abnormal molar mass, degree of dissociation and association of solutes.

Suggested Books:

1. Physical Chemistry, 7th Edition, P. W. Atkins and Julio de Paula, Oxford Univ. Press, 2002.
2. The Elements of Physical Chemistry, 3rd Edition Peter Atkins, OxfordUniv. Press, 2000.
3. Physcial Chemistry – A molecular Approach Donal A. Mcquarrie and John D. Simon, Viva Low- priced Student Edition, 2001.
4. Introduction to Physical Chemistry, 3rd Edition Mark Ladd, Cambridge Low-Priced Edition,
5. Text Book of Physical Chemistry, S.Glasstone, MacMillan India Ltd., 1998.
6. Principles of Physical Chemistry, 4th Edition, B. R. Puri and L. R. Sharma and M. S. Pathania, S. L. N. Chand & Co., 1987
7. Text Book of Physical Chemistry, P. L. Soni., S. Chand & Co., 1993.
8. Physcial Chemistry Alberty, R. A. and Silbey R. J. John Wiley & Sons, 1992.
9. Physical Chemistry, G. M. Barrow, McGraw Hill, 1986.
10. Physical Chemistry, 3rd Edition, Gibert W. Castellan, Narora Publishing House, 1985.
11. Text Book of Polymer Science, Billmeyer, Dr. F. W. John Wiley & Sons, 1984.
12. Basic Physical Chemistry, Walter J. Moore, Prentice Hall, 1972.



B. Sc. Chemistry (H)
3rd Year
Paper III B

Time 3 Hours **Full Marks: 50**

Inorganic Chemistry

Ten Questions to be Set, Five Questions are to be Answered
(Numerical Questioned to be Included

I Hard and Soft Acids and Bases (HSAB) 7 Hrs

Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.

II Metal-ligand Bonding in Transition Metal Complexes 10 Hrs

Limitations of valence bond theory, an elementary idea of crystal-field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.

III Magnetic Properties of Transition Metal Complexes 7 Hrs

Types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula. L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.

IV Electron Spectra of Transition Metal Complexes 7 Hrs

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

V Thermodynamic and Kinetic Aspects of Metal Complexes 5 Hrs

A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes.

VI Organometallic Chemistry 10 Hrs

Definition, nomenclature and classification of organometallic compounds. Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief account of metal-ethylenic complexes and homogeneous hydrogenation, mononuclear carbonyls and the nature of bonding in metal carbonyls.

VII Bioinorganic Chemistry **10 Hrs**

Essential and trace elements in biological processes, metalloporphyrins with special reference to haemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}. Nitrogen fixation.

VIII Silicones and Phosphazenes **4 Hrs**

Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

SUGGESTED BOOKS:

1. Advanced Inorganic Chemistry, 6th Edition F. A. Cotton, G. Wilkinson, C. A.
2. Murillo and M. Bochmann-John Wiley & Sons, 1999.
3. Concise Inorganic Chemistry, 5th Edition J. D. Lee, Blackwell Science, 2001.
4. Inorganic Chemistry, 4th Edition J. E. Huhee, E. A. Keiter and R. I. Keiter, Pearson Education Asia, 2000
5. Inorganic Chemistry, ELBS 2nd Edition D. F. Shriver, P. W. Atkins and C. H. Langford, Oxford Univ. Press 2002.
6. Environmental Chemistry A. K. De, Wiley Eastern Ltd., 1999.
7. Nuclear and Radiation Chemistry Sharma B. K, Goel Publishing House, 1987.
8. Modern Inorganic Chemistry W. L. Jolly, McGraw Hill Co.
9. Principles of Inorganic Chemistry B. R. Puri and L. R. Sharma, Jauhar S. P-S. N. Chand & Co., 1998
10. Inorganic Chemistry, 3rd Edition (ISE) A. G Sharpe, Addison Wesley, 1989.
11. Basic Inorganic Chemistry, 3rd Edition F. A. Cotton, G. Wilkinson, P. L. Gaus-John Wiley & Sons, 1995.
12. Essential Chemistry, International Edition R. Chang, McGraw Hill Co, 1996.
13. University Chemistry, 4th Edition (ISE) B. H. Mahan & R. J. Myers, Addison Wesley, 1989.
14. Essential Trends in Inorganic Chemistry C. M. P. Mingos, Oxford Univ Press, 1998
15. Chemistry, 3rd Edition P. Atkins &L.Jones, W. H. Freeman & Company, 1997.
16. Modern Chemistry, 4th Edition D. W. Oxicby, H. P. Gills & N. H. Nachtrieb, Saunders College Publishing, 1998.
17. Fundamental Concepts of applied Chemistry, Jayashree Ghosh, S Chand Publications.
18. Industrial Chemistry, B. K. Sharma, Goel Publishing House

B. Sc. Chemistry (H)
3rd Year
Paper III C

Time 3 Hours **Full Marks: 50**

Organic Chemistry

Ten Questions to be Set, Five Questions are to be Answered

I Spectroscopy (Numerical Questioned to be Included) 10 Hrs

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

II Organometallic Compounds 4 Hrs

Organomagnesium compounds: the Grignard reagents-formation, structure and chemical reactions.
Organozinc compounds: formation and chemical reactions.
Organolithium compounds: formation and chemical reactions.

III Organosulphur Compounds 4 Hrs

Nomenclature, structural features, Methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine.

IV Heterocyclic Compounds 8 Hrs

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.
Introduction to condensed five and six- membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

V Organic Synthesis *via* Enolates 6 Hrs

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of ethyl acetoacetate: the Claisen condensation. Keto-enol tautomerism of ethyl acetoacetate.
Alkylation of 1,3-dithianes. Alkylation and acylation of enamines

VI Carbohydrates

8 Hrs

Classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of monosaccharides. Cyclic structure of D(+)-glucose. Mechanism of mutarotation.

Structures of ribose and deoxyribose.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

VII Amino Acids, Peptides, Proteins and Nucleic Acids

6 Hrs

Classification, structure and stereochemistry of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Preparation and reactions of α-amino acids.

Structure and nomenclature of peptides and proteins. Classification of proteins. Peptide structure determination, end group analysis, selective hydrolysis of peptides. Classical peptide synthesis, solid–phase peptide synthesis. Structures of peptides and proteins. Levels of protein structure. Protein denaturation/renaturation.

Nucleic acids: introduction. Constituents of nucleic acids. Ribonucleosides and ribonucleotides. The double helical structure of DNA.

VIII Fats, Oils and Detergents

2 Hrs

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils. Saponification value, iodine value, acid value. Soaps, synthetic detergents, alkyl and aryl sulphonates.

IX Synthetic Polymers

4 Hrs

Addition or chain-growth polymerization. Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers.

Condensation or step growth polymerization. Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes.

Natural and synthetic rubbers.

X Synthetic Dyes

8 Hrs

Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo

SUGGESTED BOOKS:

1. Organic Chemistry, Paula YurkanisBruice, Prentice Hall, 2005.
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum, 1990.
3. Organic Chemistry, Vol I & II, I.L. Finar, ELBS, 1986, 1991, 2005
4. Organic Chemistry, R.T. Morrison and R. N. Boyd, Prentice Hall, 1991
5. Organic Chemistry, Maitland Jones, Jr., W. W. Norton & Company
6. Advanced Organic Chemistry, O.S. Bahl and A. Bahl., S. Chand & Co. 1995
7. Advanced Organic Chemistry, J. March, John Wiley & Sons, 2008.
8. Understanding Organic Reaction Mechanisms, A. Jacobs, CambridgeUniv Press, 1998.
9. Organic Chemistry, M. K. Jain, Nagin& Co., 1987
10. A Guide to Mechanism in Organic Chemistry, P.Sykes, Orient Longman, 2005.
11. Organic Spectroscopy, V. R. Dani, Tata McGraw Hill, 1998.
12. Organic Spectroscopy, W.Kemp, ELBS IV Edition, 1998.
13. Synthetic Drugs, G. R. Chatwaal, Himalaya Publications, 2000.
14. Steriochemistry of Organic Compounds, Ernest L. Eliel, Samuel H. Wilen, Wiley India Edition, 1994.

B. Sc Chemistry (Hons)
Paper VIII
Lab Course

Time: 6 Hours **Full Marks: - 50**

PHYSICAL CHEMISTRY

Chemical Kinetics

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of ethyl acetate.
4. To study kinetically the reaction rate of decomposition of iodide by H_2O_2.

Distribution Law

1. To study the distribution of iodine between water and CCl_4.
2. To study the distribution of benzoic acid between benzene and water.

Colloids

1. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi- and trivalent anions.

Viscosity, Surface Tension

1. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions.
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).

Transition Temperature

1. Determination of the transition temperature of the given substance by thermometric/dialometric method (e.g. $MnCl_2.4H_2O/SrBr_2.2H_2O$).

Phase Equilibrium

1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system.
2. To construct the phase diagram of two component (e.g. diphenylamine -benzophenone) system by cooling curve method.

Thermochemistry

1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process.
2. To determine the enthalpy of neutralisation of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionisation of the weak acid/weak base.
3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber cycle.

Electrochemistry

(a) To determine the strength of the given acid conductometrically using standard alkali solution.

(b) To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically.

(c) To study the saponification of ethyl acetate conductometrically.

(d) To determine the ionisation constant of a weak acid conductometrically.

(e) To titrate potentiometrically the given ferrous ammonium sulphate solution using

$KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox potential of Fe++/Fe+++ system on the hydrogen scale.

Refractometry, Polarimetry

(a) To verify law of refraction of mixtures (e.g., of glycerol and water) using Abbe's refractometer.

(b) To determine the specific rotation of a given optically active compound.

Molecular Weight Determination

(a) Determination of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.

(b) Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.

Colorimetry

To verify Beer – Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance.

$KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox potential of Fe++/Fe+++ system on the hydrogen scale.

Refractometry, Polarimetry

(a) To verify law of refraction of mixtures (e.g., of glycerol and water) using Abbe's refractometer.

(b) To determine the specific rotation of a given optically active compound.

Molecular Weight Determination

(a) Determination of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.

(b) Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.

Colorimetry

To verify Beer – Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance.

Suggested Books:

Experiments in General Chemistry, C.N.R. Rao and U.C. Agarwal, East-West Press.

Experiments in Physical Chemistry, R.C. Das and B. Behra, Tata McGraw Hill.

Advanced Practical Physical Chemistry, J.B. Yadav, Goel Publishing House.

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B.Sc. Part I

Chemistry (Subsidiary)

(BCH-Sub I)

Ten Questions are to be Set, Six Questions are to be Answered selecting two from each (Numerical Questioned to be Included)

Group - A

PHYSICAL CHEMISTRY

1. Gaseous State: Kinetic Theory of Ideal Gases, postulate, Derivation. Deduction of Ideal gas law from Kinetic gas Equation. RMS, Most Probable and Average speed. Vander Waal's Equation for real Gases.

2. Chemical Equilibrium: Law of Mass Action and its Derivation. Applications of Law of Mass Action to Gases, liquid and heterogeneous system. Relation among Kp, Kcand Kx. Le chateliar Principle.

3. Theory of Dillute Solutions: Colligative properties of Dilute Solution. Osmosis and Osmotic Pressure, Raoult's law of lowering of Vapour Pressure, Elevation of Boiling Point and Depression in Freezing Point. Determination of Molar Mass using above methods.

4. Thermodynamics: Important thermodynamic terms. Work, Heat and Internal Energy.First Law of Thermodynamics. Enthalpy, Heat Capacity, relation between C_P and C_V Work done in isothermal process. Adiabatic process for ideal gases and their Relation between P-V, V-T and P-T using Adiabatic process for Ideal Gases.

5. Thermochemistry: Various types of Enthalpy of Reaction. Relation between qp and qv. Hess's Law of constant Summation. Bond Energies and their calculations. Bomb Calorimeter.

Group B

INORGANIC CHEMISTRY

1. Atomic Structure: Bohr theory of Hydrogen atom, atomic spectra of Hydrogen atom. Moseley Equation. Concept of wave function, Four Quantum Numbers, shape of the orbitals, Isotopes (detection, Separation and concept of Atomic Mass).

2. Periodic Classification of Elements: Consequences of Atomic size, ionization energy, electron affinity (electron gained Enthalpy), electronegativity, oxidation state.

15/10/2015

3. Chemical Bonding : Ionic Bond , covalent Bonds , Hydrogen Bond, Van der Waal's Forces. Lattice Energy , Bond Lande Equation ,Born Haber Cycle. Sigma and Pi bonds concept of Hybridization. VSEPR Theory , Structures, Shapes ,Bond angles of covalent species.

4. The Chemistry of individual elements and their compounds in periods and groups: With reference to Electronic configuration, stability of oxidation states ,acid base behaviors , general chemical reactions and their compounds., structure , Shapes of their compounds and ions of the following :

(a) Group 18 (Noble Gases): Discovery, isolation and separation. Fluorides and oxides of Zenon (Structures, Shapes , Hybridization)

(b) Group 11. Silver and Gold: Extraction metallurgy important chemical reactions of silver and gold and their important chemical reactions.

(c) Group 13: Preparation, properties and uses of BF_3, BCl_3, Boric Acid and Borax. Hydrides of Boron (non detailed study).

Group C
ORGANIC CHEMISTRY

1. **General Idea of Organic Chemistry:**
   (a) Structures and Shapes of Organic Compounds.
   Tetravalency of Carbon : Hybridization of sp^3 ,sp^2 and sp.
   (b) Classification and Nomenclature of Organic Compounds.
   (c) Elementary idea of Inductive effect, Electromeric and Mesomeric Effect.
2. **Alcohol:** Classification, Nomenclature, Primary ,Secondary and Tertiary alcohol. Glycerol and its Preparation and its chemical reaction.
3. **Aldehydes and Ketones:** General Methods of their Preparation ,Chemical Properties and their derivatives. Nitriles.
4. **Amines:** (a) Classification (b) Preparation. (c) Properties (d) Separation (e) Distinction and (f) Basicity of amines.
5. **Carboxylic Acid:** General Methods of Preparation , Properties of monocarboxylic acids.Their derivatives such as esters , acid chlorides , acid anhydride and amide

B. Sc Part I

Subsidiary Lab Course

Time 5 Hours **Full Marks: 25**

Group-A

Inorganic Lab Practical

1. Qualitative Inorganic: Analysis of mixture containing four radicals.

Basic Radicals: Ag^{+}, Hg^{+}, Pb^{2+}, Cu^{2+}, Hg^{2+}, Bi^{3+}, Cd^{2+}, Sn^{2+}, Sn^{4+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Ni^{2+}, Co^{2+}, Zn^{2+}, Mn^{2+}, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}.

Acid Radicals: CO_3^{2-}, S^{2-}, SO_4^{2-}, NO_3^{-}, NO_2^{-}, halides. **12 Marks**

Group-B

Organic Lab Practical

2. Preparation of Organic Compounds:

(a) Acetylation of aniline.

(b) Nitration of nitrobenzene.

(c) Oxidation of benzaldehyde.

(d) Hydrolysis of esters (Ethyl benzoate and methyl salicylate). **8 Marks**

3. Record of class work and Viva-voce **5 marks**

15/10/2013

B.Sc. Part II
Chemistry (Subsidiary)
(BCH-Sub II)

Ten Questions are to be Set, Six Questions are to be Answered selecting two from each (Numerical Questioned to be Included)

Group – A
PHYSICAL CHEMISTRY

1. Chemical Kinetics: Rate of reaction, First order and second order reaction Determination of order of reaction by various methods. Arhenius equation and Activation energy.

2. Electrochemistry ; Conductance of weak and strong electrolytes. Specific Conductance, Equivalent Conductance and Molecular Conductance and their experimental Determination. Variation of Conductance with dilution. Kohlrausch's Laws.

3. Ostwald's Dilution Law : Concepts of pH and pOH. Buffer Solutions. Modern concept of Acid and Bases (Bronsted- Lowry and Lewis concept). Common ion effect, Solubility Product and its application.

4. Electrochemical Cell : Reversible and Irreversible Cells. Origin of Standard Electrode Potential. Applications of emf measurements.(Solubility Product and Valency calculation)

5. Radioactivity : Alpha, Beta and Gamma rays. Isotopes, Isobar and Isotones.Group Displacement Law. Balancing of Nuclear Reactions. Half Life and Average Life. Artificial Radioactivity, Carbon Dating.

Group - B
INORGANIC CHEMISTRY

1. General Chemistry of d- Block Elements (With Reference to 3d): Electronic Configuration, Oxidation State, Atomic and Ionic Radii, Magnetic Properties ,Standard Reduction Potentials , Ionization energies , colour of important transition metal compounds. Catalytic Properties of metals.

2. Coordination compounds: - Double salts and Coordination compounds, nomenclature. Werner's theory, Isomerism, valence bond theory.

3. Chemistry of Individual Elements and their compounds: - The study of following group w.r.t.

(i) electronic configuration (ii) Oxidation states and their stabilities (iii) Acid-base characters

(iv) General Chemical reaction of elements and their compounds

(v) Identification of acid and basic radicals of their respective compounds

(vi) Shapes and structure of the covalent compounds formed by the elements

Group 16:- Sulphur, Sodium thiosulphate, Oxiacid of sulphur.

Group 6:- Chromium, extraction metallurgy, chromium (III) and chromium (VI)

Group 17:- Halogens: Properties and uses of fluorine, hydrogen fluoride and oxiacids of chlorine.

Group 7:- Manganese: Occurrence extraction metallurgy, chemical properties and uses. Important compounds of Mn IV and Mn VII.

Ozone and hydrogen peroxide: Preparation, chemical properties and structure and uses.

4. Gravemetric Estimation: - Silver, Copper, Nickel, Barium, Chloride and Sulphate.

5. Volumetric Estimation: - Silver, Copper and Chloride.

Group - C

ORGANIC CHEMISTRY

1. Isomerism: (a) Structural Isomerism and

(b) Sterio Isomerism.

2. Dicarboxlic Acid: Oxalic Acid and Malonic Acid (Synthesis and Chemical Reaction).

3. Hydroxy Acid: Lactic Acid, Tartaric Acid, (Isolation, Synthesis,Chemical reaction and Constitution). Optical Isomerism of Lactic Acid and Tartaric Acid. Elements of symmetry, resolution of racemic compounds.

4 . Carbohydrate: Classification, Nomenclature and Open chain and ring Structure of Glucose.

5. Benzene and its monosubstituted Product: Toluene, Nitrobenzene, Aniline , Benzene Diazonium Chloride ,Phenol, Benzaldehyde, Benzoic Acid (Preparation, Properties and uses).

Name reactions: Perkin Reaction, Friedel- Craft Reaction, Cannizzaro's Reaction, Kolbe's Reaction, Riemer - Tieman Reaction, Sandmeyer Reaction.

6. Elementary Idea of electrophilic Reaction: Mechanism of Nitration, Halogenations and Sulphonation in aromatic rings. Directive Influence of – OH, - NH_2, - CH_3, - NO_2 and -SO_3H group.

B. Sc Part II

Subsidiary Lab Course

Time 5 Hours **Full Marks: 25**

Group-A

Inorganic Lab Practical

1. Volumetric Analysis

(a) Acidimetry and Alkalymetry.

(b) Permaganometry, Dichromatry and Iodometry.

(c) Gravimetry estimation of Cl, Ag, Mg. **12 Marks**

Group-B

Organic Lab Practical

1. Detection of Nitrogen and Sulphur and halogen in Organic Compound.

2. Detection of the following functional group in Organic Compounds:

(i) -OH (Phenolic) (ii) -CHO (iii) C = O (iv) –COOH (v) $-NH_2$ (vi) $-NO_2$

3. Detection of melting and boiling points of Organic Compounds **8 Marks**

3. Record of class work and Viva-voce **5 marks**

15/10/2015 15/10/2015 15/10/15 15/10/2015