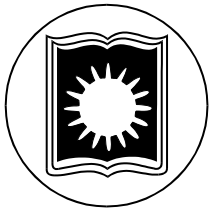
DEPARTMENT OF CHEMISTRY
FACULTY OF SCIENCE



THE UNIVERSITY OF RAJSHAHI

Syllabus for
The Degree of Master of Philosophy (M.Phil.)/ Doctor of Philosophy (Ph.D.) in Chemistry
Session: 2017-2018

Department of Chemistry, University of Rajshahi
January, 2018

DEPARTMENT OF CHEMISTRY

Syllabus for
M. Phil / Ph.D. Courses

The following courses each of 100 marks are designed for M..Phil / Ph.D. students as per ordinance passed by the Academic Council held on 17-18/10-98 (decision no. 37 of 196th Academic Council) and approved by the Syndicate at its 351st meeting held on 22/10/98.

Course Number	Course Title
Chem 611	Physical Chemistry - X
Chem 612	Physical Chemistry - XI
Chem 613	Physical Chemistry - XII
Chem 621	Organic Chemistry - VIII
Chem 622	Organic Chemistry - IX
Chem 623	Industrial Chemistry - II
Chem 631	Inorganic Chemistry - IX
Chem 632	Inorganic Chemistry - X
Chem 633	Analytical Chemistry – II
Chem 634	Bioinorganic Chemistry

* Marks Distribution:

(a) Close Book Examination : 75

(b) Class Assessment : 25

A student must complete **two courses** out of **the above ten courses**. The courses will be assigned to a research fellow on the recommendation of supervisor(s) and approved by the departmental **Chairman** / **Academic Committee**.

Course : Chem 611
Physical Chemistry-X
Examination : 4 hours
Full marks : 100

1. **Physical Properties of Gases:** Kinetic molecular theory, equation of states and transport phenomena of gases.
2. **Chemical Thermodynamics:** Thermochemistry, statistical thermodynamics, non-equilibrium or reversible thermodynamics.
3. **Chemical Equilibria, Phase Rule and Distribution law**.
4. **Electrochemistry:**Electrolytic conductance, electrolytic transference and Ionic equilibria.
5. **Chemical kinetics, Photochemistry and Catalysis**.
6. **Surface Chemistry:** Adsorption and Colloid chemistry.

Recommended Books:

1.	Gurdeep Raj	:	Advanced Physical Chemistry
2.	N. Kundu and V.K. Jain	:	Physical Chemistry
3.	P.N. Atkins	:	Physical Chemistry
4.	G.M. Barrow	:	Physical Chemistry
5.	W.S. Moore	:	Physical Chemistry
6.	K.J. Laidler	:	Chemical Kinetics

Course: Chem 612
Physical Chemistry-XI
Examination : 4 hours
Full marks : 100

1. **Specific Heat of Solids and Gases, Wave Mechanics, Atomic and Molecular Spectra**.
2. **Chemical Crystallography and Liquid Crystals**.

3. **Solutions:** Properties of binary solutions viz. viscosity, molar volume, surface tension, refractive index, etc., theories of binary liquid in liquid and liquid in solid solutions. Determination of molecular weight of macromolecules.

4. **Electric Properties of Molecules:** Dipole moment, physical properties and chemical constitution.

5. **Magnetochemistry and Magnetic Properties of Matter**.

Recommended Books:

1. Gurdeep Raj : Advanced Physical Chemistry
2. N. Kundu and V.K. Jain : Physical Chemistry
3. P.N. Atkins : Physical Chemistry
4. G.M. Barrow : Physical Chemistry
5. W.S. Moore : Physical Chemistry

Course: Chem 613
Physical Chemistry-XI
Examination : 4 hours
Full marks : 100

1. **Chemical Kinetics:**

(a) **Theories of reaction rates and reactions in solution:** Effect of time, pH, extractant concentration, co-ions, solvent and temperature etc. on extractive reactions in solution. Kinetics of complex reactions in solution, solvation, ion-association, chelation and chain polymerization.

(b) Reactions on surfaces and in solid state, adsorption isotherms, mechanism of surface reactions (uni- and bimolecular), electronic theorie ts of chemisorption and heterogeneous catalysis, enzyme catalysis, reactions in the solid state.

(c) **Chararistics of Complex Reactions:** Rate equations, steady-state treatment, detection and estimation of atoms and radicals; solvation, ion-association, chelation and chain polymerization.

2. **Ion-exchange and Solvent Extraction:** Metal extraction systems, chelating extractant/ligands, LIX reagent. Solvent extraction; extractability of metal chelates, stoichiometry of extraction. Purification of reagents and extracted complexes. Equilibration, selectivity, stripping, synergism, loading capacity, and modifier. Scope and significance of solvent extraction process and coordination chemistry of metal ions, solvent effect on the spectra of metal chelates.

3. **Physico-analytical Techniques:** Determination of molecular weight, atom-atom ratio, decomposition /melting point, pH, conductance, coefficient of viscosity, optical rotation and magnetic susceptibility measurements. Running of IR, UV-VIS, NMR spectra and their interpretation. Trace analysis using spectrophotometer, elemental analysis, gravimetric analysis, complexometric titrations. Reporting and interpretation of analytical data and correlation. X-ray analysis, structure of solid complexes.

4. **Ligand Substitution Reactions:** Labile and inert complexes, fundamentals of mechanistic concept, classification of ligand substitution mechanisms (reactions), attacking reagents (neocleophilic and electrophilic).

   Square-planar substitutions: Models (steric and orbital), rate law, trans- effect, mechanism, factors affecting the rate of substitution.

   Octahedral substitutions: Rate law, mechanism, steric effect, role of leaving group, acid and base hydrolysis (aquation), anation.

Recommended Books:

1. G.H. Morrison and H. Freiser : Solvent Extraction in Analytical Chemistry
2. Y. Marcus and A.S. Kertes : Ion Exchange and Solvent Extraction of metal complexes
3. P.W. Selwood : Magnetochemistry
4. K.J. Laidler : Chemical Kinetics
5. Walter J. Moore : Basic Physical Chemistry.
6. C.H. Langford and H.B. Gray : Ligand Substitution Processes
7. W.U. Malik, G.D. Tuli and R.D. Madan : Selected Topics in Inorganic Chemistry
8. F.A. Cotton and G. Wilkinson : Advanced Inorganic Chemistry

Course: Chem 621
Organic Chemistry - VIII
Examination : 4 hours

Full marks : 100

1. Designing organic synthesis. Retrosynthetic analysis of organic compounds containing multifunctional groups.
2. Synthesis of Natural products using new and special methodology. Use of organometallics in organic synthesis. Application of metal complexes as intermediates / catalysts in organic synthesis.

Course: Chem 622
Organic Chemistry - IX
Examination : 4 hours
Full marks : 100

1. A comprehensive study of NMR (Proton and Carbon-13), IR, UV-Vis and Mass spectroscopy and their applications for structural elucidation of different types of organic compounds.

Course : Chem-623
Industrial Chemistry - II
Examination - 4 hours
Full Marks : 100

1. **Polymers:** a) General idea: Polymers and their classification, addition and condensation polymerization, molecular weight measurement, degree of polymerization, polydispersity and molecular weight distribution, glass transition temperature and factors influencing it.

   b) Polymerization techniques: General chemistry of different types of polymerizations with special emphasis on their preparations and mechanisms of formation. Emulsion and dispersion polymerizations: details of their preparation and mechanism of particle formation, effects of different parameters on their size.

   c) Polymer Colloids: Definition, properties of colloids, general optical, electrical and kinetic properties, coagulation, stabilization of polymer colloids, a review of the applications of polymer colloids in biomedical, water purification and coating.

2. **Natural Fibers:** Jute; composition, solubility, improvement of jute fiber for textiles, Cotton and silk: composition, chemistry involved in processing of cotton and silk.

3. **Paints & Varnishes:** Definitions, classification, constituents, purposes of coating, methods of applications, cure and paint failure, importance of resin in paint formulation.

4. **Leather Technology:** Composition of hide or skin, chemistry of pre-tannage and tanning processes, physical and mechanical properties, principles of dyeing tanned leather, applications and prospects.

Recommended Books:

1.	P.A. Lovell & and M S El- Aasser	:	Emulsion Polymerization Emulsion Polymers
2.	D.C. Blackley and V.R. Gowariker	:	Emulsion Polymerization
3.	N.V. Fiswanathan & J. Shreedhar	:	Polymer Science
4.	Badger and Banchero	:	Introduction to Chemical Engineering
5.	R.N. Shreve	:	Chemical Process Industries

Course : Chem 631
Inorganic Chemistry - IX
(Inorganic and Organometallic Compounds)
Examination : 4 hours
Full Marks : 100

1. **Chemical Bonding:** The covalent bond: Valence bond theory and molecular orbital theory, symmetry and overlap symmetry of molecular orbitals, electron density in molecules, delocalization of covalent bonding in ionic solids.

2. **Bonding in Organometallic and Acid complexes:** Bonding in metalcarbonyls, metalnirosyls, metal-alkene, metal-arenes, metal-phosphorus and metal-CS_2. The major distinction between classical and organometallic compounds.

3. **Electronic Spectra:** Selection rule, Racah parameters (B & C parameters), spectra and energy level diagrams, orgel diagrams (d^1 - $3d^1$, d^1, d^6 tetrahedral and octahedral, d^2 octahedral and tetrahedral complexes), Tanabe-sugano diagrams.

4. **Charge Transfer Spectra:** Ligand to metal charge transfer transitions, metal to ligand charge transfer, the effect of coordination number and streochemistry upon charge transfer energies, solvent dependence of charge transfer bonds, spectroscopic terms and charge transfer energies.

5. **Role of Solvents in Reactions and Purification of Inorganic Compounds:** General idea about aqueous, non-aqueous, polar and non-polar solvents. Preliminary idea about unstable, moisture sensitive and temperature dependent reactions. Preliminary idea about purification of inorganic and organometallic compounds:

   (i) TLC, (ii) Column chromatography, (iii) Paper chromatography, (iv) Gas chromatography, (v) Crystallization technique.

6. **(i) Magnetic Moments and Conductance Measurement Techniques:** Application to coordination compounds.

   (ii) Infrared Spectra: Infrared spectral studies of the ligands and their complexes including symmetry of the molecules and the number of infrared active bands especially metalcarbonyls, ligands: >C=O, CO, CH_2=CH_2, CH≡CH, NH_3, C=N, >C=S

   (iii) Nuclear Magnetic Resonance: NMR (^{1}H, ^{13}C, ^{31}P) studies of the ligands and their complexes, ligands : $\bar{H}$, PPh_3, $OPPh_3$, >C=O, CO, C=C, C≡C, C_6H_6, C_5H_5. Temperature dependent NMR and fluxional molecules. Coupling and coupling constant due to metal and phosphorus.

7. **X-ray Studies:** Single crystal x-ray crystallagraphy of first and second series trasition metal complexes (simple and cluster compound) including mixed ligand Werner types and organometallic types with O, N donors ligands.

Recommended Books:

1. Ramesh Kapoor, S.K.Vasisht and R.S. Chapra : Inorganic Chemistry (2nd edition)
2. F. Albert Cotton & Wilkinson : Advanced Inorganic Geoffrey Chemistry (5th ed.)
3. Robort W. Hay : Bio-Inorganic Chemistry
4. H.J. Emeleus and A. G. Sharpe : Modern Aspects of Inorganic Chemistry
5. A.B.P. Lever : Inorganic Electronic Spectroscopy (2nd ed.)
6. James E. Huheey : Inorganic Chemistry (3rd Ed.)
7. J.D. Lee : A Concise of Inorganic Chemistry (3rd ed.)
8. K.F. Purcell and J.C. Kotz : Inorganic Chemistry
9. Paul S. Pregosin, Roland Kunz : ^{31}P and ^{13}C NMR of Transition W. Metal Phosphine Complexes (springer -Verlag, 1979).
10. C.A. McAulitfe and W. Levason : Studies in Inorganic Chemistry Phosphine, Arsene and Stibine Complexes of Transition Elements

Course : Chem 632
Inorganic Chemistry - X
(Inorganic and Organometallic Reaction & Mechanisms)
Examination : 4 hours
Full Marks : 100

1. **Chemical Kinetics:** Rate laws; integrated rate expressions: first order reaction, reversible first and second order reactions. Activation parameter; classification of mechanism.
2. **Ligand Substitution Reactions on Square Planar Complexes:** Substitution reactions; cis-trans effect, other effects on the rate; leaving-group effects, effects of the entering nucleophile and solvent.

3. **Substitution Reactions of Octahedral Werner-type complexes:** Kinetics; leaving-group and chelate effects

   Acid and base catalysis: Acid catalysis, base Catalysis.

4. **Organometallic Substitution Reactions:** Ligand bonding; metal carbonyl substitution reactions; metal effects on reactivity, solvent effect, nature of the intermediate, stereochemistry of Co dissociation.

5. **Oxidative-Addition and Reductive Elimination:**

   Oxidative addition; kinetic studies, mechanisms.

   Reductive-Elimination: Mechanistic investigation.

6. **Homogeneous Catalysis:** General consideration; homogeneous hydrogenation of alkenes; $RH(PPh_3)_3Cl$, $HRh(PPh_3)_3$ CO. Hydroformylation reaction; polymerization of alkenes.

7. **Stereochemical Nonrigidity:** Coordination number isomerism; four-coordinated complexes, five-coordinated complexes, six coordinated complexes. Metal-metal bonded systems; metal carbonyl dimers, trinumber clusters, tetranumber cluster, hydrido cluster compound.

8. **Oxidation -Reduction Reactions:**

   Electron transfer: theoretical consideration.

   Outer sphere electron-transfer: Inner sphere mechanism; nature of the bridging ligand, other considerations for inner sphere reactions.

Recommended Books:

1. Ramesh Kapoor, S.K Vasisht and R.S. Chapra : Inorganic Chemistry (2nd edition)
2. F. Albert Cotton & Geoffrey Wilkinson : Advanced Inorganic Chemistry(5th Edition)
3. Robort W. Hay : Bio-Inorganic Chemistry
4. H.J. Emeleus and A. G. Sharpe : Modern Aspects of Inorganic Chemistry

5. A.B.P. Lever : InorganicElectronic Spectroscopy (2nd edition) `
6. James E. Huheey : Inorganic Chemistry (3rd Edition)
7. J.D. Lee : A Concise of Inorganic Chemistry (3rd edition)
8. K.F. Purcell & J.C. Kotz: Inorganic Chemistry
9. Paul S. Pregosin, Kunz : ^{31}P and ^{13}C NMR of Transition Roland W. Metal Phosphine Complexes (springer -Verlag, 1979).
10. C.A. McAulitfe and W. Levason : Studies in Inorganic Chemistry of Phosphine, Arsene and Stibine complexes of Transition Elements

Course-Chem 633
Analytical Chemistry - II
Examination : 4 hours
Full Marks : 100

1. **Fundamentals:** Significant figure conventions, units of mass, weight and concentrations, statistical treatment of analytical data.
2. **Sampling:** Air, Water and Soil: Sample preservation and treatment.
3. **Analytical Methods:**
   a. Molecular electronic absorption and fluorescence.
   b. Atomic absorption and emission.
   c. Potentiometry, and
   d. Voltammetry.
4. **Trace Analysis:** Problems and precautions.
5. **Analyses of Environmental Samples for Pollutants:** Pb, As, Cd, Cr, CO, CO_2, NO_x, SO_x and hydrocarbons.

Course Chem 634
Bio-inorganic Chemistry
Examination: 4 hours
Full marks-100

1. **General Background:**

   General survey, metal and nonmetals, Primordial development, Trace metals, (a survey), metal complexes, Hard and soft acids and bases, inert and labile complexes, The structure of proteins, the active site of enzymes, Nucleosides, nucleotides and nucleic acids, sugars, blood.

2. **Physical Methods :**

   Introduction, Electronic absorption spectra, optical rotatory dispersion and circular dichroism, Electron spin resonance, Nuclear magnetic resonance, X-ray crystal structure determination. Potentiometric determination of formation constants.

3. **Biochemistry & Medicine, Biomolecules and Biochemical methods**.

4. **Structures and Functions of Proteins and Enzymes:**

   Amino acids: Introduction, Biomedical importance, protonic equilibria of amino acids, Reactions of amino acids, separatory techniqnes of amino acids.

5. Biosynthesis of fatty acids, keto genesis, metaabolism of unsaturated fatty acids, acylglycerols & sphingolipids. Lipid transport and storage.

6. **Biochemistry and Disease:** Introduction, Biochemical basis of disease, Genetic disease, Diagnosis and treatment. Case Histories.

Recommended Books:

1.	J.E. Huhcey:	:	Inorganic chemistry: Principle of structure and Reactivity
2.	R.W.Hay:	:	Bioinorganic chemistry.
3.	Cotton and Wilkinson:	:	Advanced Inorganic chemistry, 5th dition(1980)
4.	R.K.Murray,Peter A. Mayes D.K. Granner, V.W.Rodwell	:	Harpers Biochemistry

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