

Dhaka University Affiliated Colleges
Course Outline for Second year B.Sc. Honours in Chemistry

The weightage for each 4 credit theory course is 100 marks and for each two credit theory course is 50 marks. 20 % of the marks of the theory courses are allotted to class assessment of which 15 % marks are for incourse examination and 5% marks are for class attendance. For 2 credit courses there will be a one-hour incourse examination and for 4 credit courses, it would be arithmetical mean of two one hour in-course examinations. There will be a 4-hour course final examination (for 4 credit courses) and 2½ hour course final examination (for 2 credit courses) of 80 % marks. The allocation of marks to each 4 credit practical course is 100 and 2 credit practical course is 50. The duration of each practical examination will be 6 hours. Each student has to appear in a viva-voce examination of 2 (two) credits.

Course Type	Course No.	Course Title	Credits	
Major	CH 7201	Chemical Thermodynamics	2	
	CH 7202	Electrochemistry	2	
	CHL 7203	Physical Chemistry Laboratory I	2	
	CH 7221	Organic Chemistry II	2	
	CH 7222	Stereochemistry	2	
	CH 7241	Chemistry of the Representative Elements	4	
	CHL 7242	Quantitative Inorganic Analysis	4	
	CH 7243	Oral / Seminar	2	
Major Total [Theory = 12, Lab = 6 and Oral = 2]			20	
Proposed minor courses				
Minor	PM 7211	Optics	2	
	PM 7223	Electricity and Magnetism	2	
	PML 7204	Physics Practical	2	
	Any three Mathematics courses to be taken			
	MTM 7203	Ordinary Differential Equation	2	
	MTM7 204	Numerical Analysis	2	
	MTM 7202	Calculus II	2	
	MTM 7205	Mathematical Methods	2	
Minor Total [Mathematics = 6 and Physics = 6]			12	
2nd Year Total Credits [Major = 20 and Minor = 12]			32	

CH 7201 Chemical Thermodynamics

(2 Credits)

Course Content

- 1. Thermodynamics:** Energy and the first law of thermodynamics, enthalpy, the concept of the second law of thermodynamics, the direction of spontaneous change, dispersal of energy, heat engines, Carnot cycle, state function, entropy, Clausius inequality, changes in U , H , and S with T and P , criterion for equilibrium in closed systems, Helmholtz and Gibbs functions, heat engines, refrigerator and heat pumps, properties of exact differentials, Maxwell's relations - reversible, irreversible, adiabatic and isothermal process, heat capacity, Joule-Thomson expansion and Joule-Thomson coefficient, internal pressure, temperature and pressure dependence of Gibbs function, chemical potential and fugacity, partial molar quantities and their determinations, Gibbs-Duhem equation, chemical potential in mixtures, Nernst heat theorem, statement of the third law, absolute entropy, applications and limitations of third law.
- 2. Phase Equilibrium:** Phase, component and degrees of freedom, phase rule, thermodynamic interpretation of phase diagram of water, thermodynamics of phase change, Clapeyron and Clausius-Clapeyron equations, thermodynamic derivation of colligative properties.

- 3. Chemical Equilibrium:** Extent of reaction, reactions and the Gibb's function, the equilibrium law, thermodynamic equilibrium constant, exergonic and endergonic reactions, coupled reactions, feasibility of reactions, Ellingham's diagram, thermodynamics of ATP.
- 4. Applications of Thermodynamic Principles:** Energy conversion, efficiencies of power plants, energy balance in close and reactive systems, fuels and combustion, adiabatic flame temperature, ignition, flash point.

Books Recommended

1. Physical Chemistry, P. Atkins and J. de Paula.
2. Physical Chemistry, G. W. Castellan.
3. Chemical Thermodynamics: Basic Concepts and Methods, R. M. Rosenberg and I. M. Klotz.
4. Thermodynamics for the Chemists, S. Glasstone.
5. Physical Chemistry, G. M. Barrow.
6. Physical Chemistry, R. A. Alberty.
7. Elementary Principles of Chemical Processes, R. M. Felder and R.W. Rousseau.
8. Physical Chemistry, R. J. Silbey, R. A. Alberty and M. G. Bawendi.

CH 7202 Electrochemistry

(2 Credits)

Course Content

- 1. Conductance:** Concept of weak and strong electrolytes, specific conductance (κ) and molar conductance (λ) and their measurements, variation of κ and λ with the concentration of weak and strong electrolytes, Kohlrausch's law of independent ion migration and its application, transport number and its determination, factors affecting transport number, applications of conductance in kinetic measurements, acid-base titrations, precipitation titration, determination of the solubility of sparingly soluble salts, water quality index, etc., impact of conductance on biochemistry, ion channels and ion pumps.
- 2. Acid-base Equilibria:** pH of weak acid and weak base solutions, Henderson-Hasselbalch equation, indicators, pK_a of an indicator, pH range of an indicator, theories of acid-base indicator, buffer mechanism, buffer capacity, salt hydrolysis.
- 3. Theories of Electrolytes:** Theories of strong electrolytes: Debye-Hückel limiting law and its test, determination of activity co-efficient, Debye-Hückel-Onsager equation: limitations and applications.
- 4. Galvanic Cells and Their Applications:** Galvanic cells, half cells, electrode potentials, e.m.f. of cells, Nernst equation, different types of electrodes: standard hydrogen electrode, secondary reference electrodes, concentration cells, measurement of e.m.f. of a cell: compensation method: use of high impedance voltmeters, measurements of electrode potentials, cell reactions, half cell reactions, thermodynamic functions from e.m.f. measurements: standard free energy changes, equilibrium constants, activities, quinhydrone and hydrogen ion selective electrodes. Analytical applications: e.m.f. measurements: feasibility of a reaction, potentiometric titration, ion selective electrodes for analytical purposes, pH titration, electro-gravimetry, rechargeable battery: dry cell and fuel cell, solar cells, photoelectrochemical generation of hydrogen from water.
- 5. Industrial Applications of Electrochemistry:** Chloro-alkali industries, electrometallurgy, electrochemical treatment of industrial effluents.

Books Recommended

1. Physical Chemistry, P. Atkins and J. de Paula.
2. Physical Chemistry, G. W. Castellan.
3. Physical Chemistry, G. M. Barrow.
4. Physical Chemistry, R. A. Alberty.
8. An Introduction to Electrochemistry, S. Glasstone.

CH 7221 Organic Chemistry II

(2 Credits)

Course Content

- 1. Nitro and Nitroso Compounds:** Synthesis, resonance, reactivity and reactions of aliphatic and aromatic nitro and nitroso compounds. Reduction of nitro compounds.

- Amino Compounds:** Synthesis, physical and chemical properties of amino compounds, basicity of amines, reactions of amino compounds, diazonium, azo and hydrazo compounds, uses with special emphasis on synthetic utility of diazonium compounds, separations of primary, secondary and tertiary aliphatic amines, quaternary compounds and N-oxides, oxidation of amines, optical activity of quaternary nitrogen containing compounds.
- Other Compounds Containing Carbon-Nitrogen Bond:** Structure, shape, synthesis, physical and chemical properties of nitriles, thiocyanates, carbamates and ureas, imines, oximes, enamines and azides.
- Organo-Sulphur and Organo-Phosphorus Compounds:** Structure, shape, synthesis, physical and chemical properties of thiols, alkyl-, dialkyl-, alkylaryl phosphines and sulphides, phosphonium salts, optical activity of phosphorus and sulphur compounds.
- Organometallic Compounds and Their Uses in Organic Synthesis:** Synthesis of organometallic compounds containing lithium, magnesium, copper, cadmium, zinc and their synthetic utility.
- Heterocyclic Compounds:** Synthesis, structure, physical and chemical properties of heterocyclic compounds: pyridine, pyrrole, furan, thiophane, quinoline and isoquinoline.
- Dyes:** Theory of colour and constitution, classification of dyes and synthesis of some typical dyes: Methyl Orange, Congo Red, Crystal Violet, Phenolphthalein, Alizarin and Thymol Blue.

Books Recommended

- Organic Chemistry, I. L. Finar, Volume 2.
- Organic Chemistry, T. W. G. Solomons, C. B. Fryhle and S. A. Snyder.
- Introduction to Organic Chemistry, A. Streitwieser, C. H. Heathcock and E. M. Kosower.
- Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon.
- Organic Chemistry, S. H. Pine.
- Organic Chemistry, J. E. McMurry.

CH 7222 Stereochemistry

(2 Credits)

Course Content

- Fundamentals of Stereochemistry:** Stereochemistry and stereoisomerism, stereochemical representation of structures (Fischer projection, Newman, Sawhorse, conversion among these forms).
- Optical Activity and Optical Isomerism:** Cause of optical activity, chirality (asymmetry and dissymmetry), symmetry elements, optical isomerism, diastereoisomers, enantiomers, epimers, anomers, meso- and racemic compounds, racemic modifications and their resolution, atropisomerism: biphenyls, allenes and spirans.
- Geometrical Isomerism:** Conditions, configurations of geometrical isomers- *cis-trans*, *syn-anti*, *E/Z* system, physical properties and configurational assignments of geometrical isomers, interconversion of geometrical isomers, geometrical isomerism of polyenes, carbon-nitrogen, nitrogen-nitrogen double bonds and cyclic compounds (*cis-trans* isomerism in substituted cyclohexane).
- Conformation and Conformational Analysis:** Conformations and conformers, conformations of ethane, propane, n-butane and butane-2,3-diol, cyclohexane, methyl- and dimethylcyclohexanes, conformations of cyclobutane, cyclopentane and cyclohexane and their stability, conformation of mono and disubstituted cyclohexanes (1,3-diaxial interaction, butane-gauche interaction).
- Configuration:** D and L, *threo* and *erythro*, R and S absolute configurations, determination of the configurations of simple organic compounds, absolute and relative configurations and their correlation.
- Stereochemistry of the Fused-Ring System and Bicyclic System:** Stereochemistry of decalines, fused- and bicyclic bridges-ring systems, Bredt's rule and its exception in flexible ring systems.

Books Recommended

- Stereochemistry of Carbon Compounds, E. L. Eliel.
- Organic Chemistry, I. L. Finar, Volume 2.
- Organic Chemistry, T. W. G. Solomons, C. B. Fryhle and S. A. Snyder.
- Organic Stereochemistry, G. Hallas.
- Organic Chemistry, R. T. Morrison and R. N. Boyd.
- Stereochemistry: Conformation and Mechanism, P. S. Kalsi.
- Organic Chemistry, S. H. Pine.

CH 7241 Chemistry of the Representative Elements

(4 Credits)

Course Content

- 1. Hydrogen:** Introduction, resemblance with alkali metals and with halogens, various forms of hydrogens - atomic hydrogen, nascent hydrogen, occluded hydrogen and *ortho* and *para* hydrogen molecules, isotopes of hydrogen, water gas: water gas shift reaction, reducing action, binary hydrides and their classification, the hydrogen bond, structure of ice, hydrates and water clathrates, hydrogen - the prospective future fuel.
- 2. The Alkali Metals:** Occurrence and extraction, comparative properties, hardness, ionization energies, cation sizes and polarization, flame coloration, alkali metal solutions in liquid ammonia and other solvents, hydration, hydration radii, reducing strength, anomalous behavior of Li, diagonal relation between Li and Mg, binary compounds - oxides, hydroxides, salts, complexation of alkali ions, organometallic compounds and crown ethers, biological importance alkali metals.
- 3. The Alkaline Earth Metals:** Occurrence and extraction, comparative properties, ionization energies, cation sizes and polarization, flame coloration, stability and lattice energy, reducing character, anomalous behaviour of Be, diagonal relationship between Be and Al, compounds of beryllium and calcium, hardness of water, organometallic and complex compounds, biological role of Mg and Ca ions.
- 4. The Boron Family:** General properties, occurrence, extraction of aluminium, electron deficient compounds, chemistry of boron hydrides, Lewis acid character of BX_3 compounds, stability of BX_4^- anions, borates and boric acid, borazine and its similarity and dissimilarity with benzene, polyhedral boranes, chemistry of aluminium, aqua ion, alum, toxicity of $Tl(I)$ ion.
- 5. Carbon and Its Congeners:** Introduction, structure and allotropy of the elements, catenation, structure of graphite and diamond, carbanion, carbonium ion, carbides, oxides of carbon, CO - a toxic pollutant, carbonic acid, multiple bonding in carbon and silicon, silicates, classification of silicates, structure of silicates, lead and its toxicity, inert pair effect, stability of $2+$ oxidation state in the latter elements, radiocarbon dating.
- 6. The Nitrogen Family:** General properties, catenation, anomalous nature of nitrogen, nitrogen fixation, nitrogen hydrides and their derivatives, NH_3 as a non-aqueous solvent, hydrazine, hydroxylamine, azides, oxides and oxoacids of nitrogen, allotropes of phosphorus, oxides and oxoacids of phosphorus, phosphazenes and cyclophosphazenes, comparing the valency of N and P, arsenic as a water pollutant.
- 7. The Chalcogens:** General properties, anomalous nature of oxygen, uses of dioxygen, dioxygen as a ligand, hemoglobin and dioxygen, ozone: its production and importance in stratosphere, CFCs and destruction of ozone layer, tropospheric ozone and its toxicity, ionic and covalent oxides, peroxides and superoxides, allotropes of sulfur, oxides and oxoacids of sulphur, acid rain and SO_2 .
- 8. The Halogens:** Occurrence, comparative properties, colours and physical states of dihalogens, trends in bond dissociation energies, solid form and metallic luster of iodine, electrolytic production of F_2 and Cl_2 , hydrogen halides, bridging halides, interhalogen compounds: classification, structures, physical and chemical properties, pseudohalogens, polyhalogens.
- 9. The Inert Gases:** Occurrence, isolation, chemistry and uses of noble gases, xenon compounds - fluorides, oxides and oxoacids, complexes of xenon, krypton compounds, chemistry of radon, clathrate compounds of noble gases.

Books Recommended

1. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw.
2. Introduction to Modern Inorganic Chemistry, S. Z. Haider.
3. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson and P. L. Gaus.
4. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann.
5. Inorganic Chemistry, T. Moeller.
6. Inorganic Chemistry, D. F. Shriver, P. W. Atkins and C. H. Langford.
7. Principles of Descriptive Inorganic Chemistry, G. Wulfsberg.
8. Concepts and Problems in Inorganic Chemistry, M. S. Sethi and P. S. Raghavan.

CHL 7203 Physical Chemistry Laboratory I

(2 Credits)

Course Content

- 1. Determination of Molecular Weights:** Volatile liquids and non-volatile solids.
- 2. Experiments Involving Equilibrium**

- (a) Determination of partition coefficient.
 - (b) Determination of equilibrium constant of a reaction.
 - (c) Determination of molecular association and dissociation.
 - (d) Determination of solubility of a solute at different temperatures.
- 3. Thermochemical Measurements**
- (a) Determination of heat of neutralization of a strong base by a strong acid.
 - (b) Experiments involving the application of Hess's law.
- 4. Electrochemical Measurements**
- (a) Measurement of cell constant of a conductance cell.
 - (b) Measurement of specific and molar conductance.
 - (c) Conductometric titration.
 - (d) Measurement of e.m.f. and standard electrode potential.
 - (e) e.m.f. titration.
 - (f) pH-titration.
- 5. Study of Molecular Structure by Measurements of Some Physical Properties viz.**
- (a) Viscosity and density.
 - (b) Surface tension.
 - (c) Vapour pressure.
- 6. Measurement of the Colligative Properties of Solutions**
- (a) Depression of freezing point of water.
 - (b) Elevation of the boiling point of a liquid.
- 7. Experiments Involving Kinetics**
- (a) Kinetic study of a clock reaction.
 - (b) Effect of temperature on reaction rates.

Books Recommended

1. Practical Physical Chemistry, A. Findlay.
 2. Experimental Physical Chemistry, G. P. Matthews.
 3. Experiments in Physical Chemistry, F. Daniels, J. H. Matthews, P. Bender and R. A. Alberty.
 4. Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcomb, A. R. Denoro and R. M. W. Rickett.
 5. Findlay's Practical Physical Chemistry, B. P. Levitt edited.
 6. Experiments in Physical Chemistry, D. P. Shoemaker and C. W. Garland.
 7. Chemistry Experiments for Instrumental Methods, D. T. Sawyer, W. R. Heinman and J. M. Beebe.
- (The books recommended for theoretical courses are also imperative).

CHL 7242 Quantitative Inorganic Analysis

(4 Credits)

Course Content

- 1. Data Collection and Processing:** Introduction to analytical balance, volumetric glassware, reagents and standard solutions, calibration of weights and glassware, uncertainty in measurements, accuracy and precision, standard deviation, systematic error, random error, probable error, propagation of error, rounding off, significant figures, primary and secondary standard substances.
- 2. Volumetric Analysis:** The principle of volumetric analysis, preparation of standard solutions, classifications of methods of volumetric analysis,
 - (i) Neutralization Method: Standardization of sodium hydroxide solution using oxalic acid solution as a primary standard titrant, standardization of hydrochloric acid using standard sodium hydroxide solution, determination of acetic acid content in vinegar, determination of carbonate in washing soda.
 - (i) *Oxidation-Reduction Method:* Standardization potassium permanganate using standard oxalic acid solution, determination of Fe(II) using standard permanganate solution, determination of Fe(II) using potassium dichromate solution as primary standard titrant, determination of Fe(II) and Fe(III) in a Fe(II)-Fe(III) mixture.
 - (ii) *Iodometric Method:* Standardization of sodium thiosulphate solution using dichromate solution, iodometric determination of copper, iodometric determination of Fe(III) using Cu_2I_2 as catalyst, iodometric determination of sulfite.

- (iii) *Precipitation Method*: Preparation of standard silver nitrate solution, standardization of ammonium or potassium thiocyanate solution, determination of chloride by Volhard's method.
 - (iv) *Complexometric Method*: Preparation of standard EDTA solution, complexometric determination of copper using Fast sulphon Black as indicator, zinc using Eriochrome Black T as indicator, nickel using murexide as indicator, determination of hardness of water.
- 3. Gravimetric Analysis:** Determination of calcium as oxalate, aluminium as 8-hydroxyquinolate, sulfate as barium sulfate.
- 4. Analysis of Mixtures:** Separation and quantitative determination of copper and nickel, iron and manganese, copper and zinc from the respective binary admixtures using suitable methods.

Books Recommended

1. Vogel's Textbook of Quantitative Inorganic Analysis, 3rd/4th edition.
2. Elementary Quantitative Analysis – Theory and Practice, W. J. Blaedel and V. W. Meloche.
3. Quantitative Chemical Analysis, R. B. Fischer and D. G. Peters.
4. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch.
5. Analytical Chemistry, G. D. Christian.

PM 7211 Optics (2 Credits)

PM 7223 Electricity and Magnetism (2 Credits)

PML 7204 Physics Practical (2 Credits)

Course content of these three courses are to be provided by the Department of Physics

MTM 7203 Ordinary Differential Equation (2 Credits)

MTM 7204 Numerical Analysis (2 Credits)

MTM 7202 Calculus II (2 Credits)

MTM 7205 Mathematical Methods (2 Credits)

Course content of these four courses are to be provided by the Department of Mathematics

Minor Courses Offered by the Department of Chemistry for the Students of Other Departments

CM 7201 Selected Topics of Physical Chemistry

(2 Credits)

Course Content

- 1. Thermodynamics:** The first law, internal energy, enthalpy, enthalpy changes in chemical and physical processes, reversible and irreversible processes, Joule-Thomson effect, heat capacity of gases, thermo-chemistry, measurement of enthalpy changes, spontaneous processes, heat engine and Carnot cycle, concept of entropy, free energy, conditions for equilibrium, chemical potential, chemical equilibrium, thermodynamics of biological processes.
- 2. Electrochemistry:** Electronic and electrolytic conduction, electrolysis and its practical application, quantitative aspects, electrolytic dissociation, conductance and its measurements, ionic migration and transference numbers, electrochemical cells, cell reaction, Nernst equation, potentiometric titration of redox reactions.
- 3. Chemical Kinetics:** Reaction rate, its measurement, rate law, rate equation, factors that influence the rate, order, molecularity of simple reaction, simple collision theory, activation energy, Arrhenius equation, catalysis (simple treatment).
- 4. Phase Equilibrium:** Phase equilibrium diagrams of water, CO₂ and sulfur, mixture of miscible liquids, partially miscible liquids, fractional distillation, eutectic mixture, the vapour pressure of salt hydrates, phase rule.
- 5. The Colloidal State and Adsorption:** Colloidal sol, properties of lyophobic and lyophilic sol, colloidal electronics, protective colloids, preparation and properties of colloids, emulsion, gels, adsorption, physical adsorption and chemisorption, sorption isotherms.

Books recommended

1. Physical Chemistry, P. Atkins and J. de Paula.
2. An Introduction to Electrochemistry, S. Glasstone.
3. Chemical Kinetics, K. J. Laidler.
4. Principles and Applications of Photochemistry, R. P. Wayne.
5. Physical Chemistry of Macromolecules: Basic Principles and Issues, S. F. Sun.

CM 7222 Biologically Important Organic Compounds

(2 Credits)

Course Content

- 1. Fats and Oils:** Occurrence, composition of fats and oils, hydrolysis of fats and oils, various uses of fats and oils, saponification of fats and oils, iodine value and saponification value of fats and oils, saturated and unsaturated fatty acids.
- 2. Amino Acids, Peptides and Proteins:** Structure and configuration of amino acids, isoelectric points, preparations and reactions of amino acids and peptides, proteins, their classifications and functions, basic structure of protein.
- 3. Carbohydrates:** Definition, classification and constitution of monosaccharides, ring structure of monosaccharides and their conformations, action of acids and bases on sugars, epimers, anomers and anomeric configurations, reaction of monosaccharides, di- and tri-saccharides, their structures and compositions, polysaccharides - cellulose, starch and their constituents.

- Vitamins:** Occurrence, symptoms due to deficiency of vitamins, chemistry of vitamins A, B₁, B₁₂, E and K and their structures.
- Synthesis of Drugs and Their Actions in Biological Systems:** Sulpha drugs - sulfonamide, sulphapyridine, sulpha-guanidine and sulphadiazine, antibiotics - penicillin, antimalarials – quinine.
- Insecticides, Fungicides and Herbicides:** (i) Organochlorine compounds - DDT, gammexane, methoxychlor and heptachlor, (ii) Organophosphorus compounds - malathion, parathion, dimecron and diazinon.

Books Recommended

- Organic Chemistry, R. T. Morrison and R. N. Boyd, and Problems and Their Solution in Organic Chemistry.
- Organic Chemistry, S. H. Pine and J. B. Handrickson.
- Organic Chemistry (Vol. 1 and 2), I. L. Finar, and Problems and Their Solution in Organic Chemistry.
- A Text Book of Organic Chemistry, M. U. Ahmed and A. J. Mian.
- Fundamentals of Organic Chemistry, T. W. Solomons.
- Introduction to Organic Chemistry, A. Streitwieser and C. H. Heathcock.
- Advanced Organic Chemistry, J. C. Roy, (In Bangla).

CM 7241 Chemistry of the Elements

(2 Credits)

Course Content

- Chemistry of the Representative Elements:** Chemistry of alkali and alkaline earth metals, chemistry of elements of Gr IIIA-VIIA with particular reference to B and Al, C and Si, N and P, O and S and chemistry of the halogens.
- Metallurgy of Some Selected Elements:** Occurrence and extraction of Al, Fe, Cu and Zn.
- The First Transition Series and the Lanthanides:** The metals and their oxidation states, aqueous chemistry, chemistry of their oxides and halides, lanthanides and actinides - their occurrence, general features, oxidation states, oxides and hydroxides.
- Coordination Chemistry:** Coordination compounds, ligands, coordination number, nomenclature, structures of complex compounds: Werner's primary and secondary valency concept, Sidwick's electronic concept, valence bond theory, isomerism in coordination compounds, coordination compounds in biological systems.
- Inert Gases:** Occurrence and isolation, chemistry of xenon, and their application.
- Elements of Radiochemistry:** Isotopes, Radioactivity, natural and artificial radioactivity, half life and average life of radioelements, radioactive decay, nuclear reactions, nuclear reactors - working principle and uses.

Books Recommended

- Concise Inorganic Chemistry, J. D. Lee.
- Modern Inorganic Chemistry, R. D. Madan.
- Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson and P. L. Gaus.
- Introduction to Modern Inorganic Chemistry, S. Z. Haider.
- Chemistry, S. S. Zumdahl.