

Revised Syllabus 2014

M.Sc. II: Inorganic Chemistry

Semester III (Each course of 4 credits)

Course	Title	No. of Lectures
CHI326	Organometallic Chemistry & Homogeneous catalysis	48
CHI330	Inorganic Reaction Mechanism, photochemistry and Magnetic Properties of Coordination Compounds	48
CH-331	Physical Methods in Inorganic Chemistry	48
CHI332	Bioinorganic & Inorganic medicinal chemistry	48

Each course has 12 contact hours

Semester IV (Each course of 4 credits)

Course	Title	No. of Lectures
CHI-430	Inorganic Polymers and Heterogeneous Catalysis	48
CHI-431	Material science – I: Inorganic Solid state materials	48
CHI-432	Material science – II: Nanomaterials	48
CHI-445	Inorganic Chemistry Applications in Industry, Environment and Medicine	48

Each course has 12 contact hours

M.Sc. II: Inorganic Chemistry Practical (Each course of 6 credits)

Course	Title
CHI387	Experiments & computer applications in Inorganic Analysis
CHI388	Inorganic Instrumental analysis and synthesis of inorganic materials
CHI488	Project work/Extended experiments.

Equivalence of previous Syllabus

	New Syllabus 2014 Pattern		Old Syllabus 2008 Pattern
CHI-326	Organo metallic Chemistry & Homogeneous catalysis	CH-326	Organometallic compounds of Transition metals & Homogeneous catalysis
CHI-330	Inorganic Reaction Mechanism, Photochemistry and Magnetic Properties of Coordination Compounds	CH-330	Coordination Chemistry, Magnetism & Reaction Mechanism
CHI-331	Physical Methods in Inorganic Chemistry	CH-331	Structural Methods in Inorganic Chemistry
CHI-332	Bio-inorganic chemistry	CH-332	Bioinorganic Chemistry: Inorganic Elements in the Chemistry of life
CHI-430	Inorganic Polymers and Heterogeneous Catalysis	CH-430	Inorganic Solids & heterogeneous catalysis
CHI-431	Material science – I: Solid state and other Inorganic materials	CH-431	Materials Science
CHI-432	Materials Science-II: Nanomaterials		
CHI-445	Inorganic Chemistry Applications in Industry, Environment and Medicine	CH-445	Inorganic Applications in Industry, Biotechnology & Environmental Chemistry
CHI-387	Experiments & computer applications in Inorganic Analysis	CH-387	Experiments & computer applications in Inorganic Analysis
CHI-388	Practical Course – II	CH-388	Practical Course – II
CHI-488	Projects/Extended Practicals in Inorganic Chemistry	CH-488	Projects/Extended Practicals in Inorganic Chemistry

M. Sc. - II Inorganic Chemistry
Semester – III

CHI-326

Organo metallic Chemistry & Homogeneous catalysis

4 credits

Organo metallic Chemistry

24L + 6 T

1. Introduction & Recapitulation

d-block metal carbonyls,

2. Sigma complexes. :Synthesis,bonding,properties and applications.

hydrocarbyl compounds,

3. Metal-Carbon multiple bonded compounds

Carbene and carbynes

4. π -complexes

Alkenes

Di and polynes

5. $n^n C_n R_n$:Carbocyclic polyenes: Synthesis,bonding,properties and applications

Allyls

Pentadienyls

Cyclobutadienes

Cyclo pentadienyls

Cycloheptatrienyls

Arenes

6. Phosphine complexesSynthesis, bonding,properties andapplications

7. Metal-metal bonds

Transition metal atom clusters

Carbonyl polymers

8. Transition metal organo-metallics in organic synthesis.

As Electrophiles

Nucleophiles

Activating agents

Protecting agents

9. Fluxional Behaviour of organometallic compounds

Homogeneous Catalysis:

24L + 6T

1. Introduction to catalysis .Basic principles, Definition of activity& selectivity catalysis, homogenous vs. heterogeneous catalysis. Importance of homogenous catalysis in synthesis of high value chemicals
2. Characteristics of central metal atom &influence of attached ligands on catalytic activity
Important reaction types: oxidative addition, reductive elimination, migratory insertion, beta hydride elimination.
3. Tollman catalytic cycles
Use of spectral techniques for identification of intermediates. (IR, NMR),
4. Reactions Of olefins.
 - a. Polymerisation: Catalytic cycle for alkene Polymerisation
Metallocene catalysts-structure, special features advantages and mechanism of action.
 - b. Oxidation including catalyst separation in homogeneous catalysis
Fenton Reaction-FeBr₃/H₂O₂
Metal catalysed liquid phase oxidation
Epoxidation
Biphasic catalysis -oxidation
 - c. C-C coupling (Cativa process, Heck, Suzuki, Negeshi and cycloaddtion reactions)
5. Metathesis
6. Asymmetric catalysis

Books:

1. Organotransition Metal Chemistry Anthony F. Hill, Royal Society of Chemistry, Tutorial Chemistry Text, 2002.Chapters1-7.
2. Organometallics: A concise Introduction, Ch. Elshebroicn and A. Salzer, VCH, chapters 12-16
3. Organotransition Metal Chemistry: Applications to Organic Synthesis, S.G. Davies, Permagaon 1982.
4. Inorganic Chemistry 3rd edn D.F. Shriver and P.W. Atkins, Oxford University Press, 1999, Chapter 16.
5. Organometallic Chemistry –R.C. Mehrotra and A. Singh, 1992, Wiley
6. Principles of Organometallic Chemistry, P. Powell, Chapman & Hall
7. Organometallic Compounds, Morries, Sijlirn, IVY Publication House
8. Organometallics in Organic Synthesis – Swan & Black
9. Organometallic Chemistry - E.J. Elias and Gupta
10. Homogeneous Catalysis - G.W.Parshall

CHI-330 **4 credits**

Inorganic Reaction Mechanism, Photochemistry and Magnetic Properties of Coordination Compounds **48L + 12T**

Inorganic Reaction Mechanism: **12L**

Types of mechanisms, substitution in square planar and octahedral complexes. Electron transfer reaction, Inner and outer sphere reactions, Isomerisation reactions

Reactions of coordinated ligand **8L**

Non-chelate forming reactions, reactions of donor atoms (halogenations of coordinated nitrogen atoms, alkylation of coordinated S, N, N atoms, solvolysis of coordinated P atom) Reactions of donor atoms (nucleophilic and electrophilic behaviour of ligands) Chelate ring forming reactions (reactions predominantly involving thermodynamic template effect, kinetic effect) Chelate modifying reactions

Photochemistry: **10L**

Photochemical reactions, Prompt and delayed reactions, quantum yield, recapitulation of fluorescence & phosphorescence, photochemical reactions irradiating at d-d and CT band Transitions in metal-metal bonded systems, photochemical reactions involving chlorophyll Kinetics of excited state, processes

Other reaction types – oxidative addition, reductive elimination, methyl migration and CO insertion **2L**

Magnetic Properties **16L**

- i. Recapitulation of determination of R-S terms of d^2 & p^2 transition metal **1L**
- ii. Derivation of Van Vleck's expression. Quantisation of orbital contribution in d^1 ion & quenching in cubic crystal field **4L**
- ii. Magnetic moments based on crystal field ground term, perturbation theory and its application, spin orbit coupling operator for magnetic susceptibility and magnetic moments of T terms & A, E terms. **6L**
- iii. Anomalous magnetic moments in magnetically dilute and concentrated system in various symmetrical environments of coordination complexes. **3L**
- iv. Mixed valence compounds. **2L**

Books:

1. Inorganic Chemistry – D.F. Shriver, P.W. Atkins, C.H. Lamgford – Oxford, 2nd Edition, 1994.

2. Introduction to Inorganic Chemistry – K.F. Purcell & J.C. Kotz, Saunders, 1990 – Chapter 14.
3. Comprehensive Coordination Chemistry, Vol. I, G. Wilkinson (Ed.), Wiley, NY, 1967.
4. Mechanism of Inorganic Reactions in Solution - An Introduction, D. Benson, McGraw-Hill, Chapter 15
5. Inorganic Chemistry, J. Huheey, E.A. Keiter & R.L. Keiter, 4th Edn., Harper Collins, 1993
6. Mechanism of Inorganic Reactions- C.F. Basselo, R.G. Pearson, Wiley, NY
7. Inorganic Chemistry - Messler and Tarr - Pearson Publishers
8. Inorganic Chemistry – Harold Butler
9. Magnetism and Transition Metal Complexes – F.E. Mabbs and D.J. Machin, Chapman & Hall, London, 1973.

CHI-331

4 credits

Physical Methods in Inorganic Chemistry

48L + 12T

Principles, Instrumentation & applications of the following techniques

Thermal techniques (TG, DTA, DSC)	12L
Cyclic Voltametry	8L
Electron Spin resonance spectroscopy	10L
Mossbauer spectroscopy	6L
X-Ray Diffraction Powder & Single Crystal	8L
X-ray Photoelectron Spectroscopy	4L

Problems based on above techniques should be solved.

Books:

1. Structural methods in Inorganic Chemistry – E.A.V. Ebsworth, D.W.H. Rankin & S. Craddock, Blackwell Scientific Publication, 1987.
2. Physical Methods for Chemists-R.S. Drago, (2nd edition, Saunders)
3. Instrumental methods of Chemical Analysis – Chatwal & Anand
4. Laboratory Techniques in Electro analytical Chemistry edited by P.T. Kissinger and W.R. Heinman (1984) M. Dekker vinc (USA)
5. Dennis H. Evans, Journal of Chemical Education, vol.60, pp290 (1983).
6. P.T. Kissinger and W.R. Heinmann, Journal of Chemical Education, vol.60, pp702 (1983).
7. J.J. Van Benschoten, Journal of Chemical Education, vol.60, pp772 (1983).

8. Crystallography and its applications – L.S. Dent Glasser (Van Nostrand, 1977)
 Introduction to X-Ray Powder Diffractometry- R. Jenkins and Snyder 1996, Wiley (NY)

CHI-332	4 credits
Bio-inorganic chemistry	48L + 12T
1. Recapitulation of Biological roles of Metals and ligands	1L
*Structure, function and biochemistry of enzymes containing following metals:	
i) Zinc	6L
Zinc Fingers, Carboxy peptidase, Carbonic anhydrase	
ii) Copper	6L
Type I, Type II, Type III	
Blue Proteins Azurins, Plastocynins & Blue Oxidases	
Model compounds of Blue copper proteins	
Non Blue Proteins eg. Tyrosinase, Galactose oxidase, SOD	
iii) Cobalt	4L
Vit B12 co enzymes & model compounds	
Actions of Cobalamines	
Adenosylcobalamine as a coenzyme	
Ribonucleotide reductase	
Methylcobalamine as cofactor	
iv) Molybdenum	3L
Mo-cofactors	
Antagonism between Cu & Mo	
Hydroxylase	
v) Manganese	6L
vi) Non-haem iron	6L
vii) Biochemistry of chromium and Vanadium	3L
Vanadium proteins including bromoperoxidases	
Glucose Tolerance Factor	
Vanadium Nitrogenase	
2. Transition metal complexes as Chemical Nucleases	
3. Leaching of Precious metals by micro-organisms (different bacteria)	3L
4. Radiopharmaceuticals and MRI contrast reagents.	10L

Books:

1. Bioinorganic Chemistry: A Short Course—Rosette M. Malone Wiley Interscience, 2002.
2. Biological Inorganic Chemistry—An Introduction, Robert Crichton, Elsevier Science, 2007.
3. The biological Chemistry of the Elements: The Inorganic Chemistry of Life—J. J. R. Fraustoda Silva and R. J. P. Williams. Clarendon Press, Oxford, 1991.
4. Bioinorganic Chemistry: Inorganic elements in the Chemistry of life., An Introduction and Guide—Wolfgang Kaim, Brigitte Schwedrski John Wiley and sons, 1994.
5. Principles of Bioinorganic Chemistry –S.J. Lippard and J.M.Berg, University Science Books, 1994.
6. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life– Silva, J. J. R. Fraustoda and R. J. P. Williams; 2nd Ed. Oxford University Press, 2012.

SEM -IV

CHI - 430

4 credits

Inorganic Polymers and Heterogeneous Catalysis

48L + 12T

Descriptive chemistry of Heterogeneous Catalysis

1. Definition of catalysis, Classification of Catalytic systems, adsorption of molecules on solid surfaces, PE curves for adsorption, descriptive chemistry of chemisorption on metals, chemisorption and catalysis by metals-semi quantitative aspects, catalysis by supported and un supported bimetals, adsorption and catalysis on semiconducting oxides, selective oxidation of hydrocarbons, Different types of reactors. **3L**
2. Zeolite compounds and heterogenous catalysis **14L**
Introduction to meso-porous & micro porous materials Zeolites,
Definition, types, primary and secondary building blocks, characteristics of zeolites and their applications in catalysis.
XRD, SEM and other spectral techniques, FT-IR, Solid state NMR, Surface area by BET method, porevolume & pore structure, origin of Bronsted acidity & basicity in zeolites, techniques for determination of acidity, temperature programmed desorption of bases
3. Photocatalysis using semiconducting oxides. **4L**
4. Heterogenous catalysis using intercalation compounds. **3L**
5. Heterogenous catalysis using Pervoskite related oxides **4L**
6. Heterogenous catalysis using oxides with Scheelite structure **4L**
Ideal crystal structure, physical properties, oxidation of olefins, mechanism for catalysis by BiMoO₄, oxidation of propylene to acrolein, amino propylene to acrylonitrile, Role of bismuth in catalysis
7. Immobilisation of transition metal complex catalyst on Inorganic support: Anchored catalysts. **3L**
8. Industrial applications of heterogeneous catalysts **3L**
9. Inorganic Polymers: polysilylenes, SN, PN compounds. **4L**
10. Heteropolyacids, polyoxoanions-Molybdates, Tungstates etc. & their use as catalysts in organic synthesis. **6L**

Books:

1. Heterogeneous catalysts – principles and applications – G. C. Bond
2. Introduction to Zeolite Science and Practice – H. Van Bekkum, E. M. Flanigen, P. A. Jacobs and J. C. Janson, Elsevier, Amsterdam, 2001.

3. Catalysis – Principles and applications – B. Vishwanath, S. Shivshankar and A. V. Ramaswamy, Narosa Publishing House, New Delhi, 2004.
4. Advanced Materials in Catalysis – J. J. Burton, R. L. Garten, Academic Press, New York, 1977.

CHI-431

4 credits

Material science – I: Solid state and other Inorganic materials

48L + 12 T

Solid state materials

1. Crystal defects and Non stoichiometry, Diffusion in solids, phase transformation in solids, solid state reactions and crystal growth. Preparation methods of solids. **2L**
2. Magnetic materials **10L**
Atomic magnetism and solids, type of magnetic materials, exchange interactions, hysteresis loop and their classification, calculation of magnetic moment from saturation magnetisation, magnetic domains, examples of magnetic materials, soft & hard ferrites, structure & magnetic interactions in spinel, garnet hexagonal ferrites, application of magnetic materials
3. Superconducting materials **10L**
Definition, superconductivity, critical temperature, critical field, BCS theory, properties & classification of superconductors, high T_c superconductors, examples with structure and applications, fullerenes, intermetallic superconductors, synthesis, applications
4. Ceramic materials **7L**
Classification, dielectric properties, polarisation properties, piezo, pyro and ferroelectric properties, sol-gel process, examples and applications, oxide, carbide, boride, nitride
5. Composite materials **6L**
Definition, glass transition temperature, fibres, concrete and asphalt materials, polymer composites, application
6. Biomaterials:
Definition, Dense Hydroxyapatite Ceramics, bioactive glasses, bioactive glass ceramics, bioactive Composites. **6L**
7. Cementitious Materials **7L**
Difference between Blended & Non Portland cement
High Alumina cement
Phosphate Cements
Calcium sulphatoaluminate cement

Chemicals in Cement Hydration, hydration process, set retarders and accelerators, plasticisers, slip-casting processing

Applications.

Books

1. Solid state Chemistry: An Introduction – L.E. Smart & E.A. Moore, CRC, Taylor & Francis, 3rd Edn.
2. Materials Science & Engineering – V. Raghvan, 2nd Edn.
3. Introduction to Solids – L.V. Azaroff, 2nd Edn. 1980
4. Elements of materials science and engineering – Van Vleck, 5th Edn.
5. Insight to Speciality Inorganic Chemicals – D. Thompson, Royal Society of Chemistry, 1995.

CHI-432

4 credits

Materials Science-II: Nanomaterials

48L + 12T

1. Introduction to Nanomaterials **2L**
2. Synthesis of nanomaterials (methods such as solvothermal, sonochemical) **8L**
 - a. Oxide Nanoparticles
 - b. Zero valent metal nanoparticles
 - c. Zero valent Bimetallic nanoparticles
 - d. Semiconducting sulphides & Selenides Nanotubes, nanowires & nanowires
3. Properties and Structures **10L**
 - a. Optical and electrical properties
 - b. Electronic structure & spectral properties of semiconductor nanocrystals.
 - c. Application of Raman spectroscopy, SEM, TEM for morphology and structure **10L**
4. Photochemistry and Electrochemistry of nanoassemblies **12L**
5. Nanoporous materials **6L**
6. Biological Applications (targeted drug delivery) **6L**
7. Applications as sensors **4L**

BOOKS

1. The Chemistry of Nanomaterials edited by C.N.R.Rao, A.Muller, A.K.Cheetham—Wiley-VCH Verlag GmbH & co. Volumes 1&2
2. WTEC Panel Report on Nanostructure Science and Technology edited by Richard Siegel, Evelin Hu7M.C.RoCo—Kluwer Academic Publishers, Boston/London.
3. Nanomaterials by Dr. Sulbha Kulkarni.

4. Nanotechnology, G. Timp; Springer, AIP Press, 2012.
5. Nanoscopic Materials – Size Dependent Phenomenon, E. Roduner, RSC Publishing 2006.
6. Nanochemistry – A Chemical Approach to Nanomaterials, G. A. Ozim, A. C. Arsenault, L. Cadematiri, RSC Publishing 2009.

CHI-445 **4 credits**
Inorganic Chemistry Applications in Industry, Environment and Medicine **48L + 12T**
(Any two sections -2 credits each)

Section A

Dyes and Pigments **12L**

Introduction, naturally occurring Plant & animal pigments. Synthetic food pigments such as Sunset yellow, Allura etc. Pigments in plants – raw materials for paints. Physical properties of paints, manufacturing process of Pigments in brief. Titanium dioxide and Zinc oxide

Electrochemical Applications **12L**

Introduction to classical electro deposition of metals. Advances in electrochemical industry- modification of electrode surface, preparation & properties of modified electrodes eg, Nafion modified electrode, PVP modified electrode. Applications such as Electro catalysis, ion selective electrodes.

Section B

Application of Metal ions in medicine **2 credits**

1. Overview **3L**

Introduction, Metal Ions in diseases, Use of chelating agents, Metalloproteins as drug targets, Modes of binding with DNA, Metal complexes as Chemotherapeutic drugs and diagnostic agents.

2. Transition metal complexes as chemical nucleases **4L**

Interaction of metal complexes with DNA & RNA, Reactions of metal complexes with DNA, Nuclease activity of $\text{Cu}-(\text{o-phen})^{2+}$

3. Biomedical uses of Lithium **3L**

Chemistry of Lithium, Distribution in the body & cells, Biochemistry of Lithium and lithium isotope

4. Bismuth in Medicine **3L**

Properties of Bismuth, Bi(III) & Bi (V) compounds, Bismuth in medicine, Helicobacter Pylori bacterium, Bismuth citrate complexes, Bismuth complexes with Biomolecules

Bismuth complexes with oxygen containing molecules, thiolate ligands, Bi(III) complexes with metallothione, transferring and enzyme inhibition

5. Cis-platin based anticancer drugs **3L**

Mode of action, mechanism

6. Gold complexes **4L**

Introduction, Crysotherapy, Gold Chemistry – Au(I), Au(III) complexes, redox potentials

In-vivo metabolism, ligand displacement, Antitumor, anti-HIV, anti-arthritis

7. Vanadium as possible insulin modifiers **4L**

Introduction, Characterisation of insulin mimetic effect, Sites of action of vanadium, toxicological considerations, and improved tissue uptake

Books:

1. Uses of Inorganic Chemistry in Medicine Ed. Nicholas. P. Farrel
2. Metal Complexes as drugs and Chemotherapeutic agents.
3. The biological Chemistry of the Elements: The Inorganic Chemistry of Life—J. J. R. Fraustoda Silva and R. J. P. Williams. Clarendron Press, Oxford, 1991.
4. Bioinorganic Chemistry: Inorganic elements in the Chemistry of life., An Introduction and Guide—Wolfgang Kaim, Brigille Schwedrski John Wiley and sons, 1994.
5. Principles of Bioinorganic Chemistry –S. J. Lippard and J. M. Berg, University Science Books, 1994.

Section C

Environmental Chemistry **2 credits**

1. Introduction to waste water Analysis; Specification of treated waster water for disposal into surface water, Screening chamber, Grit Chamber, Oil& Grease removal. **3L**

2. Waste water engineering for biological treatment: Principle, role of microorganisms, ecosystem, designing of biological unit **7L**

a. Stabilisation pond

b. Aerated lagoon

c. Trickling filters

d. Anaerobic treatment

3. Biotechnology& Wastewater Management: Applications of Biotechnology for the treatment of: **9L**

a. high strength waste.

b. Primary and secondary sludge

c. Phenol & cyanide removal

d. Solid phase extraction

4. Energy sources for future: Solar energy, energy from biomass, wind towers, geothermal etc. **3L**
5. Bioaccumulation of Toxic metals: Lead, mercury, cadmium, arsenic. **3L**

Books:

1. Environmental Chemistry by A.K.Bagio
2. Principles of Environmental Chemistry by James Girard Bartlett Publishers
3. Waste Water Engineering by Calf& Eddy
4. Waste Water treatment for pollution control by Arceivala
5. Principles of water quality Control by T.H.YTebbut
6. Manual on Sewage & Sewage treatment, Ministry of Works, New Delhi.

INORGANIC CHEMISTRY PRACTICALS

CHI-387

6 credits

Minimum contact hours - 120

Experiments & computer applications in Inorganic Analysis

A. Analysis of the following samples:	
a. Two Ore -3 components	20 hrs
b. Alloy-3 components	6 hrs
c. Cement-3 components	6 hrs
d. Manganese from Tea leaves-1component	3 hrs
e. Vit –C 1-component	3 hrs
f. Flamephotometric Analysis	6 hrs
g. Ion Exchange analysis of cations/anions	4 hrs
h. Copper from fungicide	3 hrs
B. Statistical Analysis	4 hrs
Contact hrs for assessment	10 hrs

CHI-388

Practical course - II

6 credits

Part A: Inorganic Instrumental analysis and Computer applications

Magnetic Susceptibility - 2samples	12 hrs
Thermogravimetric studies - 2samples	8 hrs
Catalytic hydrogenation	3 hrs
Kinetics of Aquation/Isomerisation - 2experiments	8 hrs
Photochemical reactions using Nanoparticles	4 hrs
Table work – Four techniques	8 hrs
IR, ESR, XRD, CV, NMR	
Metal DNA interactions (Viscosity & spectrophotometry)	9 hrs
Synthetic Copper Oxidase (Copper catalysed oxidation of 2,6,disubstituted Phenols.)	4 hrs
Cyclic Voltametric study of i)Potassium ferricyanide ii) Ferrocene	8 hrs

Part B

Preparation of Inorganic compounds

Metal complexes

Trans-dichloro-bis(ethylene diamine) cobalt (III) chloride
Mn (Salen)

Mn (acac)₃

Hg [Co(SCN)₄]

Cu(o-phen)₂

Hexa thiocyanato chromate

Tris- triphenyl phosphine Nickel (II)sulphate.

Chloroaquo tetraamino cobaltic sulphate.

Fe (DTC)₃

Synthesis of Solid State Materials

Zinc Ferrite

NiO

Nickel Ferrite

Nano particles of MnO₂

CHI-388

6 credits

Project work /Extended Practicals in Inorganic Chemistry

A. Preparation and Purity of following complexes of

1. DMG
2. 8-hydroxy quinoline
3. Salicylaldoxime
4. Thiourea

With Copper, Nickel, Iron, Chromium & Manganese (any three metals)

B: Structural determination of above complexes using following techniques

- i) UV-Visible spectroscopy
- ii) Magnetic susceptibility
- iii) Thermogravimetric analysis
- iv) IR
- v) Solution conductivity

C. Introduction to literature survey