Anekant Education Society's

# Tuljaram Chaturchand College of Arts, Science, Commerce, Baramati

(Autonomous)

## DEPARTMENT OF CHEMISTRY

(Faculty of Science and Technology)

## Two Year MSc Degree Program Chemistry

## MSc Inorganic Chemistry

## (2019 Pattern)

### Choice Based Credit System Structure and Syllabus

**(To be implemented from June 2019)**

# M.Sc.-II Inorganic Chemistry
# Semester–IV

## CHI-5401: Heterogeneous Catalysis and Inorganic polymers
## (48L+ 12 T) (4credit)

**Course Objectives:**

1. Students know the approaches and various theories in heterogeneous catalysis.
2. Students understand the concept of heterogeneous catalysis.
3. To understand Descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.
4. Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique.
5. To understand Heterogeneous catalysis used in Intercalation compounds, Perovskites related oxides, Oxides with Scheelite structure.
6. To get knowledge about inorganic polymers.

**Course outcomes:**

After successfully completing this course, students will be able to:

CO1: To get knowledge about descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.

CO2: Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique

CO3: understand Heterogeneous catalysis used in Intercalation compounds, Perovskites related oxides, Oxides with Scheelite structure

CO4: To get knowledge about inorganic polymers.

CO5: Student should be able to characterize zeolite by using different methods.

CO6: Student should be able to understand concepts of chemisorption, physisorption.

CO7: Students apply their knowledge to find out applications of inorganic polymers involve in industry.

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, chemisorptions and catalysis by metals-semiquantitative aspects, catalysis by supported and unsupported bimetals, adsorption and catalysis on semiconducting oxides, selective oxidation of hydrocarbons ,different types of reactors. (6L)
2. Zeolite compounds and heterogeneous catalysis

   Introduction to meso-porous & micro porous materials: classification into micro meso and macroporous material the origin pore and its significance, distinction from condensed material

   Zeolites- Definition, types, natural and synthetic zeolites and aluminosilicate, primary and secondary building blocks, final framework structure, Lowen steine rule, sodalite and other structure, nomenclature , Atlas of zeolites structure distinction novel zeolites,

example of small, medium, large and extra-large pore zeolites general properties and application of molecular sieve. (10L)

3. Characterization of Zeolites:
   XRD, SEM and other spectral techniques, FT-IR, Solid state NMR, Surface area by BETmethod, pore volume& pore structure, origin of Brownsted acidity & basicity in zeolites, techniques for determination of acidity, temperature programme desorption of bases.(8 L)
4. Photocatalysis using semiconducting oxides. (2L)
5. Heterogeneous catalysis using intercalation compounds. (2L)
6. Heterogeneous catalysis using Pervoskite related oxides (4L)
7. Heterogeneous catalysis using oxides with Scheelite structure
   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. (4 L)
8. Immobilization of transition metal complex catalyst on Inorganic support: Anchored catalysts. Industrial applications of heterogeneous catalysis. (6L)
9. Inorganic polymers– Polysilylenes, SN and PN compounds. (6L)

**Reference 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 .Jacobsand J. C.Jahnson, Elsevier,Amsterdam, 2001.
3. Catalysis – Principles and applications – B. Vishwanath, S. Shivshankar andA.V.Ramaswamy, Narosa Publishing House, NewDelhi, 2004.
4. Advanced Materials in Catalysis- J.J.Burton,R.L.Garten,Acad.Press,NewYork,1977

Choice Based Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**: Heterogeneous Catalysis & inorganic Polymers **Course Code**: CHI-5401

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 3 | 2 | 2 | 2 | 2 | 0 | 0 | 0 |
| CO2 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| CO3 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| CO4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 |
| CO6 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| CO7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Justification for the mapping

**PO1: Disciplinary Knowledge**

CO1: to get knowledge about descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.

CO2: Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique

CO3: understand Heterogeneous catalysis used in Intercalation compounds, Perovskites related oxides, Oxides with Scheelite structure

CO4: To get knowledge about inorganic polymers.

CO5: Student should be able to characterize zeolite by using different methods.

CO6 : Student should be able to understand concepts of chemisorption, physisorption.

CO7: Student apply their knowledge to find out applications of inorganic polymers involve in industry.

**PO2: Critical Thinking and Problem Solving**

CO2: Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique

CO3: understand Heterogeneous catalysis used in Intercalation compounds, Perovskites related oxides, Oxides with Scheelite structure

**PO3: Social competence**

CO1: to get knowledge about descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.

CO2: Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique

**PO4: Research related skills and scientific temper**

CO1: to get knowledge about descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.

CO2: Get knowledge about Zeolite compounds, Characterization of Zeolite by XRD, SEM, FT-IR technique

CO3: understand Heterogeneous catalysis used in Intercalation compounds, Perovskites related oxides, Oxides with Scheelite structure

**PO5: Trans-disciplinary Knowledge**

CO1: to get knowledge about descriptive chemistry of heterogeneous catalysis it includes adsorption, absorption phenomenon, Types of reactors, catalysis by supported & unsupported bimetals.

CO5: Student should be able to characterize zeolite by using different methods.

CO6 : Student should be able to understand concepts of chemisorption, physisorption.

**PO6: Personal and Professional Competence**

CO1: Students Define/memories the terms related to-applications of nanomaterials, band theory, defect in crystal structures, some properties of nanomaterials, synthesis of nanomaterials.

**PO8: Environment and sustainability**

CO5: To get knowledge about inorganic polymers.

**PO9: Self-directed and Life-long Learning**

CO6**:** Student understand the applications of heterogeneous catalysis in research field

**CHI: 5402 -Material science I: Inorganic materials &solid state chemistry**

**(48L+12 T)(4 credit)**

**Course Objectives:**

1. To get knowledge about structure of solid and crystal defects.
2. To understand Magnetic materials, types, and applications.
3. To study about electronic and optical materials, Superconducting materials, ceramic materials, composite materials, Biomaterials and Meta materials
4. To find spinel structure of given metal ferrites
5. To differentiate between magnetic materials.
6. To understand the optical materials and their properties.
7. To identify defect in solid.

**Course outcomes:**

After successfully completing this course, students will be able to:

CO1: To get knowledge about structure of solid and crystal defects.

CO2: students differentiate the magnetic materials according to their type.

CO3: To get knowledge about electronic and optical materials, Superconducting materials, ceramic materials, composite materials, Biomaterials and Meta materials.

CO4: Student should understand the concept of luminescence.

CO5: Student should understand method of finding type of spinel of given compound.

CO6: Student will understand concept of conductivity, types of conductors and their applications.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry.

1. Structure of solids and crystal defect

a) The types of matter, classification of solids, structure of ionic crystals, Ionic crystals with stoichiometry MX, $MX_2$, spinel structure, pervoskite structure

b) Crystal defect: Classification of defect, calculation of no. of defects and average energy required for defect, diffusion in solids:Fick's $1^{st}$and$2^{nd}$law of diffusion in solids. (8L)

2. Magnetic materials: Magnetism in solids, hysteresis loop and their classification, soft and hard ferrites, spinels, garnets, applications of magnetic materials. (4L)

3. Electronic and optical materials

a) Electronic materials and applications

Conductivity: conductors, insulators, semiconductors, superconductors, temperature dependent conductivity.

Applications of semiconducting devices: metal-metal junction i.e. Peltier effect and seebeck effect, diodes, transistors ,metal-semiconductor junction

b) Optical materials and their properties

Photonic devices, photoluminescence, crystalline laser. (8L)

4. Superconducting materials

Definition of superconductivity, critical temperature, BCS theory, properties and classification of superconducting materials, High Tc and Low Tc superconductivity, superconducting oxides, intermetallic superconductors and applications. (8L)

5. Ceramic materials

Classification, dielectric properties, polarization properties, Piezo, Pyro, and ferroelectric effect of ceramics, sol-gel processing of ceramics, applications as oxides, carbides, borides and nitrides (5L)

6. Composite materials

Definition, glass transition temperature, fibers for reinforced plastic composite materials, applicationas glass fiber, carbon fiber, aramid fibers, polymer composites (5 L)

7. Biomaterials

Definition, types, bioactive glasses, bioactive glasses and bioactive composites, application of biomaterials (5L)

8. Metamaterials

Introduction, Electromagnetic, meta materials, classification, elastic meta materials, acquisition meta materials, structural meta materials, thermoelectric meta materials, Hall effect, applications. (5L)

**Reference books:**

1. Solid state chemistry by L. V. Azaroff
2. Material science and engineering byV. Raghavan
3. Inorganic chemistry by J.E.Huheey
4. Solid state chemistry by L. Smartand E. Moore
5. Solid state chemistry by D.K.Chakraborty
6. Solid state chemistry and its applications by A. R.West,John willeyandsons Singapore

Choice Based Credit System Syllabus (2019Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**:Material Science I: Solid state chemistry **Course Code**: CHI: 5402

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| CO2 | 3 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| CO3 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| CO4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| CO6 | 0 | 3 | 0 | 3 | 3 | 0 | 0 | 0 | 2 |
| CO7 | 2 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |

## Justification for the mapping

**PO1: Disciplinary Knowledge**

CO1: To get knowledge about structure of solid and crystal defects.

CO2: students differentiate the magnetic materials according to their type.

CO3: To get knowledge about electronic and optical materials, Superconducting materials, ceramic materials, composite materials, Biomaterials and Meta materials.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry

**PO2: Critical Thinking and Problem Solving**

CO2: students differentiate the magnetic materials according to their type.

CO4: Student should understand the concept of luminescence.

CO5: Student should understand method of finding type of spinel of given compound.

CO6: Student will understand concept of conductivity, types of conductors and their applications.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry

**PO4: Research related skills and Scientific temper**

CO6: Student will understand concept of conductivity, types of conductors and their applications.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry

**PO5: Trans-disciplinary Knowledge**

CO6: Student will understand concept of conductivity, types of conductors and their applications.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry

**PO6: Personal and Professional Competence**

CO1: To get knowledge about structure of solid and crystal defects.

CO2: students differentiate the magnetic materials according to their type.

CO3: To get knowledge about electronic and optical materials, Superconducting materials, ceramic materials, composite materials, Biomaterials and Meta materials.

**PO9: Self-directed and Life-long Learning**

CO4: Student should understand the concept of luminescence.

CO6: Student will understand concept of conductivity, types of conductors and their applications.

CO7: Students apply their knowledge about superconducting & semiconducting materials for making electronic devices in industry

**CHI: 5403 -Material Science-II:Nanomaterials**
**(48L+12 T)(4 credit)**

**Course Objectives:**

1. understand the concept of Nanomaterials.
2. understand the how to synthesize nanomaterials by using various methods.
3. understand properties of nanomaterials and their structural determination by using instrumental techniques.
4. understand nano porous materials.
5. To get knowledge about application of nanotechnology in medicinal chemistry and biology.

**Course outcomes:**

After successfully completing this course, students will be able to:

CO1: get knowledge about concept of Nanomaterials.

CO2: apply their knowledge & does application of nanoparticles in their research work.

CO3: get knowledge about properties of nanomaterials and their structural determination by using instrumental techniques.

CO4: identify nanoporous materials & their applications.

CO5: use their knowledge for nanopartical synthesis & does application of other fields.

CO6: find the method for characterization of nanoparticle the concept of oxide nanoparticles.

CO7: Student able to find green synthesis route of nanoparticals.

1. Introduction to Nanomaterials (2 L)
2. Synthesis of nanomaterials 1

   (Methods such as solvothermal, sonochemical, CVD, Arc discharge method ,Hydrothermal,Co precipitation, Microwave, Sol gel method, Ballmilling)

   a. Oxide Nanoparticles

   b. Zerovalent metal nanoparticles

   c. Zerovalent bimetallic nanoparticles

   d. Semiconducting sulphides & Selenides, Nanotubes, nanowires. (12 L)
3. Properties and Structures

   a. Optical and electrical properties

   b. Electronic structure & spectral properties of semiconduct or Nanocrystals.

   c. Nanotubes, synthesis, Properties and Application. (8 L)
4. Structural determination, application , morphology

   Raman spectroscopy, XRD, SEM, TEM, HRTEM, FESEM, Cryo-SEM, AFM, Scanning tunneling microscopy (10L)
5. Photochemistry and Electrochemistry of Nanoassemblies (4L)
6. Nanoporous materials (2L)
7. Applications assensor (4L)
8. Application of nanotechnology in medicinal chemistry,

Biological Applications (targeted drug delivery) (6L)

**Reference Books:**


1. The Chemistry of Nanomaterials edited by C.N.R.Rao, A.Muller, A.K.CheethamWiley-VCH VerlagGmbH&co. Volumes 1&2
2. WTEC Panel Report on Nanostructure Science and Technology edited by Richard Siegel,EvelinHu7M.C.RoCo—KluwerAcademic Publishers, Boston/London.
3. Nanomaterials Dr.Sulbha Kulkarni.
4. Nanotechnology ,G.Timp; Springer,AIPPress, 2012.
5. Nanoscopic Materials–Size Dependent Phenomenon,E. Roduner, RSCPublishing2006.
6. Nanochemistry – A Chemical Approach to Nanomaterials, G. A. Ozim, A. C. Arsenault, L.Cadematiri,RSCPublishing2009.

Choice Based Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**: Material Science-II: Nanomaterials **Course Code**: CHI:5403

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| CO2 | 3 | 3 | 0 | 3 | 3 | 2 | 0 | 0 | 0 |
| CO3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO4 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| CO5 | 2 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| CO6 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| CO7 | 0 | 2 | 0 | 1 | 0 | 0 | 3 | 3 | 3 |

## Justification for the mapping

**PO1: Disciplinary Knowledge**

CO1: get knowledge about concept of Nanomaterials.

CO2: apply their knowledge & does application of nanoparticles in their research work.

CO3: get knowledge about properties of nanomaterials and their structural determination by using instrumental techniques.

CO5: use their knowledge for nanopartical synthesis & does application of other fields.

**PO2: Critical Thinking and Problem Solving**

CO2: apply their knowledge & does application of nanoparticles in their research work.

CO4: identify nanoporous materials & their applications.

CO6: find the method for characterization of nanoparticle the concept of oxide nanoparticles.

CO7: Student able to find green synthesis route of nanoparticals

**PO4: Research relatated skills and Scientific temper**

CO2: apply their knowledge & does application of nanoparticles in their research work.

CO5: use their knowledge for nanopartical synthesis & does application of other fields.

CO6: find the method for characterization of nanoparticle the concept of oxide nanoparticles.

CO7: Student able to find green synthesis route of nanoparticals

**PO5: Trans-disciplinary Knowledge**

CO2: apply their knowledge & does application of nanoparticles in their research work.

CO4: identify nanoporous materials & their applications.

CO5: use their knowledge for nanopartical synthesis & does application of other fields.

**PO6: Personal and Professional Competence**

CO1: get knowledge about concept of Nanomaterials.

CO2: apply their knowledge & does application of nanoparticles in their research work.

**PO7: Effective citizenship and ethics**
CO7: Student able to find green synthesis route of nanoparticals

**PO8: Environment and sustainability**
CO7: Student able to find green synthesis route of nanoparticals.

**PO9: Self-directed and Life-long Learning**
CO7: Student able to find green synthesis route of nanoparticals.

## CHI: 5404- Inorganic applications in industrial and environmental chemistry (48L+12T)(4credit)

**Course objectives:**

1. To understand introduction, Classifications and applications of Dyes and pigment.
2. To get knowledge about electrochemical applications.
3. To get knowledge about wastewater management technique.
4. To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.
5. To get knowledge about photographic products industry.
6. To get knowledge about methods of electrodeposition of various metals

**Course outcomes:**

After successfully completing this course, students will be able to:

CO1: will develop critical thinking skills to apply their knowledge of environmental chemistry inreal world scenarios, considering interdisciplinary perspectives & making informative decisions.

CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole

CO3: will gain knowledge about chemical components present in water.

CO4: To understand methods of Bioremediations.

CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.

CO6: Students should understand methods of heavy metal detection from wastewater.

CO7: Students get knowledge about various types of dyes their types and applications.

### Section I- Inorganic applications in industry (24 L+ 06T) (2credit)

1. Dyes and Pigments
   a) Dyes: Introduction, classification of dyes, applications in industry
   b) Pigments: Introduction, pigments in food, naturally occurring plants and animal pigments, synthetic food pigments such as sunset yellow, allura red AC, pigments in plants, raw materials for paints, physical properties of pigments in paints, brief description of manufacturing process of commonly used pigments as a white lead,ZnO,$TiO_2$ (8L)

2. Electrochemical applications
   Introduction, electro deposition of metals, modification of electrode surface, surface modified electrodes, Nafion modified electrodes, Applications of surface modified electrode such as electro catalysis and ion selective electrodes. (8L)

3. Inorganic chemicals as metallic corrosion inhibitors
   Introduction, principle of corrosion inhibitors, corrosion as an electrochemical process, practical aspects of corrosion inhibition, anion inhibitor properties in neutral electrolyte some applications of corrosion inhibitor (cooling water circulation- once through the open system engine radiation and cooling system, central heating system), Refrigeration plants and high chloride system, water for steamraising, corrosion inhibitor for paint coating.(8L)

**Section II-Environmental chemistry (24 L+06 T) (2credit)**

1. Introduction to waste water analysis and waste water engineering for biological treatment. (6 L)
2. Biotechnology and waste water management: Applications of biotechnology for the treatment of: high strength waste, primary and secondary sludge, Phenol and cyanide removal, solid phase extraction. (6 L)
3. Bioaccumulation of toxic metals Pb, Hg, Cd, as energy sources for the future- Fuel cells and clean cars for the future (Powerball) Bioaccumulation of organic pollutants. (6L)
4. Bioremediation
   Introduction and concept, Basic facts, Factors of bioremediation, Key features of bioremediation, methods of bioremediation (6L)

**Reference books**


1. Handbook of industrial chemistry, K.H.Davis,F. S.Bernel,CBSPublishers Bangalore
2. Environmental chemistry, Girard
3. Textbook of environmental chemistry, Balram Pani
4. Insight into specialty inorganic chemicals,David Thomson
5. Environmental chemistry, Stanley Manahan10$^{th}$edition.

Choice Based Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**:Inorganic applications in industrial and environmental chemistry **Course Code**: CHI 5404

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 |
| CO2 | 0 | 3 | 0 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 0 | 0 | 0 | 2 | 3 | 2 | 3 | 0 |
| CO4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| CO5 | 3 | 2 | 0 | 2 | 0 | 0 | 2 | 2 | 2 |
| CO6 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 2 | 2 |
| CO7 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |

## Justification for the mapping

### PO1: Disciplinary Knowledge

CO1: will develop critical thinking skills to apply their knowledge of environmental chemistry in real world scenarios, considering interdisciplinary perspectives & making informative Decisions.

CO3: will gain knowledge about chemical components present in water.

CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.

CO7: Students get knowledge about various types of dyes their types and applications.

### PO2: Critical Thinking and Problem Solving

CO1: will develop critical thinking skills to apply their knowledge of environmental chemistry in real world scenarios, considering interdisciplinary perspectives & making informative decisions.

CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole

CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.

CO6: Students should understand methods of heavy metal detection from wastewater.

### PO4: Research related skills and Scientific temper

CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole

CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.

CO6: Students should understand methods of heavy metal detection from wastewater.

CO7: Students get knowledge about various types of dyes their types and applications.

### PO5: Trans-disciplinary Knowledge

CO1: will develop critical thinking skills to apply their knowledge of environmental chemistry in real world scenarios, considering interdisciplinary perspectives & making informative decisions.

CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole
CO3: will gain knowledge about chemical components present in water.

**PO6: Personal and Professional Competence**
CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole
CO3: will gain knowledge about chemical components present in water.
CO4: To understand methods of Bioremediations.

**PO7: Effective citizenship and ethics**
CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole
CO3: will gain knowledge about chemical components present in water.
CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.

**PO8: Environment and sustainability**
CO1: will develop critical thinking skills to apply their knowledge of environmental chemistry in real world scenarios, considering interdisciplinary perspectives & making informative decisions.
CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole
CO3: will gain knowledge about chemical components present in water.
CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.
CO6: Students should understand methods of heavy metal detection from wastewater.
CO7: Students get knowledge about various types of dyes their types and applications.

**PO9: Self-directed and Life-long Learning**
CO2: learn to evaluate the impact of chemical pollutants on ecosystems, human health & the environment as whole.
CO5: To study about bioaccumulation of toxic metal, energy sources for the future – fuel cells.
CO6: Students should understand methods of heavy metal detection from wastewater.

## Practical course III

### CHI-5405: Extended practical in inorganic chemistry (4 Credit)

**Course Objectives:**

1) To understand Methods of inorganic estimations.
2) To understand Methods of Inorganic preparations.
3) To understand the methods of characterization of metal complexes
4) To interpret given IR spectrum
5) To interpret given XRD spectrum
6) To understand handling of UV, IR magnetic susceptibility.

**Course outcomes:**

After successfully completing this course students will know,

CO1: Students will be able to Prepare solution of required concentration and handle the laboratory equipment.
CO2: Student able to calculate the quantity from observation of the experiment and interpret the result.
CO3:gain hands on experience in using various laboratory techniques .
CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.
CO5: Student should perform experiment accurately and able to perform calculations.
CO6: will develop critical thinking skills,apply their knowledge to troubleshoot experiments.
CO7: Student understand research ethics.

**A. Preparation and purity of complexes of:**

1. DMG with Cu, Ni, Mn
2. 8-hydroxyquinoline with Cu,Ni,Mn
3. Salicylaldoxime with Cu, Ni, Mn
4. Thiourea with Cu, Ni, Mn
5. Salen with Cu, Ni, Mn

**B. Structural determination of above complexes using following techniques:**

1. UV-visible spectroscopy
2. Magnetic susceptibility
3. Thermo gravimetric analysis
4. IR spectroscopy
5. Conductivity

**C. Report on industrial visit or study tour.**

NOTE: Preparation and purity of minimum 08 complexes along with their structure determination using all possible techniques is to be carried out.

**C. Introduction to literature survey**

**D. Case study:** A particular specific topic of scientific temper can be selected concerning with practical in structure and study report is to be submitted.

**Reference:**


1. A textbook of qualitative inorganic analysis:A.I.Vogel
2. Inorganic synthesis–King
3. Synthetic inorganic chemistry:W.L.Jolly
4. Experimental Inorganic chemistry by W.G.Palmer
5. The analysis of minerals and ores of rare elements: W.R.Schoeller, A.R.Powell, Charles, Griffin and company limited

Choice Based Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**: Extended practical in inorganic chemistry **Course Code**: CHI 5405

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| CO2 | 3 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 3 |
| CO3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| CO4 | 2 | 3 | 0 | 3 | 0 | 2 | 0 | 0 | 3 |
| CO5 | 0 | 2 | 0 | 2 | 3 | 0 | 0 | 0 | 2 |
| CO6 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| CO7 | 0 | 0 | 0 | 2 | 2 | 2 | 3 | 0 | 0 |

## Justification for the mapping

### PO1: Disciplinary Knowledge

CO1: Students will be able to Prepare solution of required concentration and handle the laboratory equipment.
CO2: Student able to calculate the quantity from observation of the experiment and interpret the result.
CO3:gain hands on experience in using various laboratory techniques .
CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.

### PO2: Critical Thinking and Problem Solving

CO1: Students will be able to Prepare solution of required concentration and handle the laboratory equipment.
CO2: Student able to calculate the quantity from observation of the experiment and interpret the result.
CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.
CO5: Student should perform experiment accurately and able to perform calculations.
CO6: will develop critical thinking skills, apply their knowledge to troubleshoot experiments.

### PO4: Research related skills and scientific temper

CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.
CO5: Student should perform experiment accurately and able to perform calculations.
CO6: will develop critical thinking skills ,apply their knowledge to troubleshoot experiments.
CO7: Student understands research ethics.

### PO5: Trans-disciplinary Knowledge

CO5: Student should perform experiment accurately and able to perform calculations.
CO7: Student understands research ethics.

**PO6: Personal and Professional Competence**

CO1: Students will be able to Prepare solution of required concentration and handle the laboratory equipment.
CO2: Student able to calculate the quantity from observation of the experiment and interpret the result.
CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.
CO7: Student understands research ethics.

**PO7: Effective citizenship and ethics**

CO7: Student understands research ethics.

**PO9: Self-directed and Life-long Learning**

CO1: Students will be able to Prepare solution of required concentration and handle the laboratory equipment.
CO2: Student able to calculate the quantity from observation of the experiment and interpret the result.
CO3:gain hands on experience in using various laboratory techniques .
CO4: learn to observe & interpret chemical reactions involving inorganic compounds, including formation of precipitate and colour change.
CO5: Student should perform experiment accurately and able to perform calculations.
CO6: will develop critical thinking skills, apply their knowledge to troubleshoot experiments.

## Practical course IV

### CHI-5406: Project work (4Credit)

**Course Objectives:**

1. To understand Research methodology
2. To understand Methods of Inorganic preparations.
3. To understand the methods of characterization of metal complexes.
4. To enhance research attitude.
5. To enhance critical thinking of students

**Course outcomes:**

CO1: To enhance & oral communications skills.
CO2: To learn effectively manage their time & resources to complete their project within Given time frame
CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO5: gain experience in designing experiments to investigate specific research questions.
CO6: develop problem solving to execute their project
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles during their projects.

This is mandatory for every student to undertake the project work on selected area of study under the guidance of project coordinator. Student must carry out entire experimental work within the stipulated time and present it briefly in the form of the dissertation at the time evaluations.

Choice Based Credit System Syllabus (2019 Pattern)

**Mapping of Program Outcomes with Course Outcomes**

**Class**: M.Sc. (Sem IV) **Subject**: Chemistry

**Course**: Project work **Course Code**: CHI 5406

**Weightage**: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

| | **Programme Outcomes(POs)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
| CO1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| CO2 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| CO3 | 3 | 0 | 3 | 3 | 2 | 0 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 2 | 2 | 0 | 2 |
| CO5 | 2 | 0 | 2 | 2 | 2 | 0 | 1 | 0 | 2 |
| CO6 | 2 | 3 | 2 | 2 | 0 | 2 | 0 | 0 | 0 |
| CO7 | 2 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 0 |

## Justification for the mapping

**PO1: Disciplinary Knowledge**

CO1: To enhance & oral communications skills .
CO2: To learn effectively manage their time & resources to complete their project within given time frame
CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO5: gain experience in designing experiments to investigate specific research questions.
CO6: develop problem solving to execute their project
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles during their projects.

**PO2: Critical Thinking and Problem Solving**

CO2: To learn effectively manage their time & resources to complete their project within given time frame
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO6: develop problem solving to execute their project
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles during their projects.

**PO4: Research related skills and Scientific temper**

CO2: To learn effectively manage their time & resources to complete their project within given time frame
CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.

CO5: gain experience in designing experiments to investigate specific research questions.
CO6: develop problem solving to execute their project
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles
during their projects.

**PO5: Trans-disciplinary Knowledge**

CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO5: gain experience in designing experiments to investigate specific research questions.
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles
during their projects.

**PO6: Personal and Professional Competence**

CO1: To enhance & oral communications skills.
CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO6: develop problem solving to execute their project
CO7: develop problem solving & critical thinking skills by encountering challenges or obstacles
during their projects.

**PO7: Effective citizenship and ethics**

CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO5: gain experience in designing experiments to investigate specific research questions.

**PO8: Environment and sustainability**

CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.

**PO9: Self-directed and Life-long Learning**

CO3: develop research skills by effectively searching for & evaluating relevant scientific literature related to their project topics.
CO4: To interpret IR, XRD, NMR and ESR spectrum of their project work.
CO5: gain experience in designing experiments to investigate specific research questions.