



University of Kerala

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| Discipline | CHEMISTRY | | | | |
| Course Code | UK5DSCCHE300 | | | | |
| Course Title | INORGANIC CHEMISTRY IIIA | | | | |
| Type of Course | DSC | | | | |
| Semester | 5 | | | | |
| Academic Level | 300 - 399 | | | | |
| Course Details | Credit | Lecture per week | Tutorial per week | Practical per week | Total Hours/Week |
| | 4 | 3 hours | - | 2 hours | 5 |
| Pre-requisites | 1. UK1DSCCHE100 2. UK4DSCCHE200 | | | | |
| Course Summary | This course deals with the electronic configuration, general characteristics, stability of oxidation states, and the formation of complexes by transition and inner transition elements, their color, magnetic, and catalytic properties, along with the preparation, properties, and uses of their specific compounds. Furthermore, the course covers coordination chemistry, organometallic and bioinorganic chemistry, metallurgy, and practical experiments in gravimetric analysis, providing students with a holistic understanding of the chemistry of transition and inner transition elements. | | | | |

Detailed Syllabus:

| Module | Unit | Content | Hrs |
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| | | INORGANIC CHEMISTRY IIIA | 75 |
| I | TRANSITION AND INNER TRANSITION ELEMENTS | | 9 |
| | 1 | Electronic Configuration and General Characteristics - Overview of transition elements and inner transition elements - Electronic configuration, oxidation states, ionization enthalpy, and enthalpy of atomization - Variation of ionization enthalpy across the 3d series - Introduction to standard electrode potentials ($E^\circ M^{2+}/M$ & $E^\circ M^{3+}/M^{2+}$) - Stability of higher oxidation states | 2 |
| | 2 | Colour, Magnetic Property, and Catalytic Property - Explanation of colour in transition metal complexes (d-d transitions) - Magnetic properties including paramagnetism and diamagnetism - Catalytic properties and their industrial applications | 1 |
| | 3 | Preparation, Properties, and Uses of Specific Compounds - Detailed study of $K_2Cr_2O_7$, $KMnO_4$ and $TiCl_4$ - Preparation methods, physical and chemical properties | 2 |

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| | <ul style="list-style-type: none"> - Industrial and laboratory uses of these compounds - Important applications of transition metals in various fields Catalytic Converters and Hydrogenation in Industry, Role of Iron and Copper in Biological Systems, Platinum-Based Anticancer Drugs in Medicine, and Use of Titanium, Chromium, and Silver in Materials and Technology. | |
| 4 | <p>Electronic Configuration, General Properties, and Reactions of Lanthanides and Actinides</p> <ul style="list-style-type: none"> - Introduction to lanthanides and actinides - Electronic configurations and general properties including oxidation state, magnetic properties, formation of coordination complexes colour conductivity. - Comparison of lanthanides and actinides with transition elements - Overview of unique properties and applications of lanthanides and actinides | 4 |
| II | COORDINATION CHEMISTRY | 18 |
| 5 | <p>Ligands and Their Classifications</p> <ul style="list-style-type: none"> - Introduction to ligands in coordination chemistry - Classification of ligands based on donor atoms: monodentate, bidentate, polydentate- - Classification based on charge: anionic, cationic, neutral - Discussion on coordination number and coordination geometry | 1 |
| 6 | <p>Nomenclature of Complexes</p> <ul style="list-style-type: none"> - Guidelines for naming coordination compounds - Nomenclature of complexes with simple and complex ligands - Examples illustrating the naming process | 1 |
| 7 | <p>EAN Rule, Chelates, and Stability of Complexes</p> <ul style="list-style-type: none"> - Explanation of the EAN (Effective Atomic Number) rule - Concept of chelation and chelating ligands - Factors affecting the stability of complexes: size and charge of metal ion, nature of ligands, and coordination number | 2 |
| 8 | <p>Bonding in Complexes - V.B. Theory</p> <ul style="list-style-type: none"> - Introduction to Valence Bond Theory (V.B. Theory) for coordination compounds - Explanation of bonding between metal ion and ligands - Hybridization and overlap of atomic orbitals - Limitations and applications of V.B. Theory | 2 |
| 9 | <p>Crystal Field Theory (CFT) Applied to Various Complex Geometries</p> <ul style="list-style-type: none"> - Overview of Crystal Field Theory (CFT) - Application of CFT to octahedral, tetrahedral, and square pyramidal complexes - Explanation of splitting of d orbitals in the presence of ligands - Factors affecting crystal field splitting: nature of metal ion, ligand strength, and geometry of complex | 2 |
| 10 | <p>Factors Affecting Crystal Field</p> <ul style="list-style-type: none"> - Detailed discussion on factors influencing crystal field splitting energy | 2 |

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| | <ul style="list-style-type: none"> - Ligand field stabilization energy (LFSE) - Effects of coordination number, ligand field strength, and nature of ligands on crystal field splitting - Applications of crystal field theory in predicting magnetic properties and colours of coordination compounds. | |
| 11 | Spectrochemical Series and Crystal Field Stabilization Energy (CFSE) <ul style="list-style-type: none"> - Introduction to the spectrochemical series - Explanation of ligands' ability to cause d-orbital splitting - Relationship between ligand strength and splitting energy - Calculation and significance of Crystal Field Stabilization Energy (CFSE) - Examples illustrating the spectrochemical series and CFSE values | 2 |
| 12 | Magnetic Properties and Color of Metal Complexes <ul style="list-style-type: none"> - Explanation of magnetic properties: paramagnetism, diamagnetism, and ferromagnetism - Factors influencing magnetic behavior in metal complexes - Relationship between electronic configuration, CFSE, and magnetic properties - Relationship between ligand field strength, d-d transitions, and color in metal complexes | 2 |
| 13 | Jahn-Teller Effect and Tetragonal Distortion <ul style="list-style-type: none"> - Introduction to the Jahn-Teller effect in transition metal complexes - Explanation of distortion in coordination geometries caused by Jahn-Teller effect - Focus on tetragonal distortion of octahedral complexes - Examples illustrating the Jahn-Teller effect in coordination chemistry | 2 |
| 14 | Application of coordination compounds in qualitative and quantitative analysis <ul style="list-style-type: none"> - Use of EDTA (Ethylenediaminetetraacetic acid) as a complexometric titrant - Examples of complexometric titrations and their significance in analytical chemistry | 2 |
| III | ORGANOMETALLIC CHEMISTRY | 9 |
| 15 | Definition and Nomenclature of Organometallic Compounds <ul style="list-style-type: none"> - Introduction to organometallic compounds - Definition and significance in chemistry - Nomenclature guidelines for organometallic compounds. | 1 |
| 16 | Classification and EAN rule - 18 and 16 electron rule <ul style="list-style-type: none"> - Classification of organometallic complexes as sigma, pi, and mixed complexes - Explanation of the 18 and 16 electron rule. - Examples illustrating the application of the rules. | 2 |
| 17 | Metal Carbonyls <ul style="list-style-type: none"> - Overview of metal carbonyls - Classification into mononuclear and polynuclear complexes | 1 |

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| | | - Bonding in meta carbonyls, Structures of metal carbonyls with and without bridging | |
| | 18 | Bonding in Organometallic Compounds - Explanation of bonding in organometallic compounds without using Molecular Orbital Theory (MOT) - Detailed analysis of bonding in specific compounds like ferrocene, dibenzene chromium, and Ziese's salt - Introduction to dinitrogen complexes and their bonding characteristics | 3 |
| | 19 | Applications of Organometallic Compounds: -Industrial applications including Ziegler-Natta catalysis in polymer synthesis, Wacker process in acetaldehyde production, and hydroformylation (oxo process)- (mechanism not expected); applications in materials science such as MOCVD for semiconductor thin films; pharmaceutical applications including cisplatin, as an anticancer drug and organotin compounds as antiparasitic agents; and environmental applications such as organomercury and organolead compounds in pollution monitoring. | 2 |
| IV | BIOINORGANIC CHEMISTRY | | 9 |
| | 20 | Introduction to elements present in biological systems. Essential and non-essential elements. Trace metal ions and bulk metal ions. | 1 |
| | 21 | Introduction to biologically important ligands. Porphyrin system: structure, importance, and biological accessibility. Corrin system: structure, importance, and biological accessibility. Introduction to prosthetic groups with emphasis on heme systems. | 2 |
| | 22 | Role of metal ions in biological systems – Biochemistry of iron, haemoglobin and myoglobin (elementary idea of the structure and mechanisms of their actions). Electron transport proteins: Cytochromes, Fe- Sulphur proteins, storage and transport of iron. | 2 |
| | 23 | Role of alkali metal ions in biological systems - Sodium-potassium pump– Biochemistry of magnesium and calcium (brief study only) | 1 |
| | 24 | Metallo enzymes and metal activated enzymes - Biochemistry of Zn – structure and functions of carboxypeptidase, carbonic anhydrase- Biochemistry of Cobalt - Vitamin B 12 and deficiency diseases | 2 |
| | 25 | Chlorophyll and photosynthesis (no mechanism) | 1 |
| V | PRACTICALS: GRAVIMETRIC ANALYSIS | | 30 |
| | | A minimum of 5 practical experiments from any sections must be performed and reported. | |
| | 26 | A. Estimations using silica crucible | 20 |
| | | Estimation of water of crystallization in hydrated Bariumchloride | |
| | | Estimation of Barium as Barium sulphate | |
| | | Estimation of sulphate as Barium sulphate | |
| | | Estimation Iron as Fe ₂ O ₃ | |
| | | Estimation Calcium as CaCO ₃ | |
| | | Estimation Aluminium as Al ₂ O ₃ | |

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| | | Estimation Magnesium as $Mg_2P_2O_7$ | |
| | 27 | B. Estimations using sintered crucible | 5 |
| | | Magnesium as oxinate | |
| | | Nickel as nickel dimethyl glyoximate | |
| | | Copper as copper thiocyanate | |
| | | Silver as silver chloride | |
| | 28 | C. Colorimetry | 5 |
| | | Determination of Fe^{3+} using thiocyanate | |
| | | Determination of ammonia using Nessler's reagent. | |

References:

1. B.R. Puri L.R. Sharma, K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
3. R. Gopalan, V.Ramalingam, *Concise Coordination Chemistry*, 1st Edn., Vikas Publishing House, New Delhi, 2001.
4. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.
5. S. Manku, *Theoretical Principles of Inorganic Chemistry*. McGraw-Hill Education; New edition (1 August 1982)
6. M.C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
7. J. E. Huheey, E.A. Keitler, R. L. Keitler, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi, 2013.
8. B.K. Sharma, *Industrial chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.
9. M.N. Greenwood, A. Earnshaw, *Chemistry of elements*, 2nd Edn., Butterworth, 1997.
10. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.
11. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.
12. James E. House, *Inorganic Chemistry*, academic press, 2008.
13. W.U. Malik, G.D.Tuli, R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand and Co., New Delhi, 2010.
14. F.A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley India Pvt. Ltd., New Delhi, 2009.

Course Outcomes

| No. | Upon completion of the course the graduate will be able to | Cognitive Level | PSO addressed |
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| CO-1 | Analyze the electronic configurations and oxidation states of transition, lanthanide, and actinide elements and their resulting physical and chemical properties, and evaluate their significance in industrial, biological, medicinal, and technological applications. | An | PSO-1,2,3 |
| CO-2 | Design and justify coordination compounds with desired geometry, stability, magnetic behavior, colour, and analytical applications by applying ligand classification, bonding theories, crystal field concepts, and structure–property relationships in coordination chemistry. | C | PSO-1,2,3 |
| CO-3 | Evaluate the structure, bonding, electron-counting rules, stability, and practical significance of organometallic compounds and metal carbonyls in relation to their industrial, pharmaceutical, materials, and environmental applications. | E | PSO-1,2,3 |
| CO-4 | Analyze the relationship between the structures and functions of different biologically important ions/groups in sustaining essential biological processes such as oxygen transport, electron transfer, ion regulation, enzymatic catalysis, and photosynthesis. | An | PSO-1,2,3,5 |
| CO-5 | Design and execute appropriate gravimetric and colorimetric analytical procedures to accurately determine the concentration or composition of inorganic substances and interpret the experimental results for quantitative analysis. | C | PSO-1,2,3 |

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: INORGANIC CHEMISTRY III A

Credits: 3:0:1 (Lecture:Tutorial:Practical)

| CO No. | CO | PO/ PSO | Cognitive Level | Knowledge Category | Lecture (L)/ Tutorial (T) | Practical (P) |
|--------|------|---------------------|-----------------|--------------------|---------------------------|---------------|
| 1 | CO-1 | PO-1,6 PSO-1,2,3 | An | F, C | L | - |
| 2 | CO-2 | PO-1,6 PSO-1,2,3 | C | F, C | L | - |
| 3 | CO-3 | PO-1,6 PSO-1,2,3 | E | C | L | - |

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| 4 | CO-4 | PO-1,2,6 PSO-1,2,3,5 | An | C | L | - |
| 5 | CO-5 | PO-1,6 PSO-1,2,3 | C | C | - | P |

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

| | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|-------------|-------|-------|-------|-------|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| CO 1 | 3 | 3 | 2 | - | - | 2 | - | - | - | - | 3 | - | - |
| CO 2 | 3 | 3 | 2 | - | - | 2 | - | - | - | - | 3 | - | - |
| CO 3 | 3 | 3 | 2 | - | - | 2 | - | - | - | - | 3 | - | - |
| CO 4 | 2 | 3 | 2 | - | 2 | 2 | 1 | - | - | - | 3 | - | - |
| CO 5 | 3 | 3 | 2 | - | - | 2 | - | - | - | - | 2 | - | - |

Correlation Levels:

| Level | Correlation |
|-------|--------------------|
| - | Nil |
| 1 | Slightly / Low |
| 2 | Moderate / Medium |
| 3 | Substantial / High |

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

| | Internal Exam | Assignment | Project Evaluation | End Semester Examinations |
|------|---------------|------------|--------------------|---------------------------|
| CO 1 | ✓ | ✓ | | ✓ |
| CO 2 | ✓ | ✓ | | ✓ |
| CO 3 | ✓ | ✓ | ✓ | ✓ |
| CO 4 | ✓ | | ✓ | ✓ |
| CO 5 | ✓ | | | ✓ |