

DEPARTMENT OF CHEMISTRY

SEMESTER IV

B Sc. (Hons) Chemistry

DISCIPLINE SPECIFIC CORE COURSE - 10(DSC-10): Coordination Chemistry and Reaction Mechanism

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
Coordination Chemistry and Reaction Mechanism (DSC-10: Inorganic Chemistry - IV)	04	03	--	01	Class 12 th with Physics, Chemistry, Mathematics	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with coordination compounds which find manifold applications in diverse areas.
- To acquaint the student with the concept of Inorganic reaction mechanism.

Learning Outcomes

By studying this course, the students will be able to:

- Explain the terms- ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.
- Discuss the various types of isomerism possible in such compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.

- Explain the meaning of the terms Δ_o , Δ_t , pairing energy, CFSE, high spin and low spin complexes and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
- Explain the reaction mechanism of coordination compounds and differentiate between kinetic and thermodynamic stability.

SYLLABUS OF DSC-10

Unit-1: Coordination Chemistry

(Hours: 28)

Werner's Coordination theory, simple problems based on this theory

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds (coordination numbers 4 and 6). Valence bond theory and its application to complexes of coordination numbers 4 and 6.

Crystal field theory, measurement of Δ_o . Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δ_o . Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry: Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory (for octahedral σ -donor, π - acceptor and π - donor complexes).

Unit-2: Stability of complexes and Inorganic Reaction Mechanism: (Hours: 17)

Brief discussion of thermodynamic and kinetic stability, Factors affecting stability of complexes, such as chelate effect, macrocyclic effect, resonance effect etc., trends in step wise formation constant, interpretation of lability and inertness based on VBT and CFT.

Introduction to inorganic reaction mechanisms, concept of reaction pathways, transition state, intermediate and activated complex. Substitution reactions in square planar complexes, factors affecting the rate of Substitution reactions in square planar complexes- such as charge effect, solvent effect and Trans- effect (Theories of trans-effect).

Practical component

Practical:

Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

(A) Argentometry

Estimation of Cl^-

- By Mohr's method
- By Vohlard's method and
- By Fajan's method

(B) Complexometric Titrations:

- Complexometric estimation of Mg^{2+} / Zn^{2+} using EDTA
- Estimation of total hardness of water samples

- (iii) Estimation of Ca^{2+} in solution by substitution method
- (iv) Estimation of Ca/Mg in drugs or biological samples.

(C) Properties of Complexes

Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, dimethyl glyoxime, glycine) by substitution method.

Essential/recommended readings

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, Fifth Edition, Pearson.
3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry**, John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G.(1999), **Advanced Inorganic Chemistry**, Wiley-VCH.
6. Sodhi G.S. (2018), **Principles of Inorganic Chemistry**, Viva Books India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), **Quantitative Chemical Analysis**, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), **Quantitative Analysis**, Sixth Edition, PHI Learning Private Limited.
4. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -11 (DSC-11): Carbohydrates, Lipids and Heterocyclic Compounds

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
Carbohydrates, Lipids and Heterocyclic Compounds (DSC-11, Organic Chemistry IV)	04	03	--	01	Class 12 th with Physics, Chemistry	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize students with the chemistry of carbohydrates, lipids, and heterocyclic compounds
- To enable students to develop novel, efficient, convenient, selective and environmentally benign synthetic methods for synthesis of heterocyclic compounds.

Learning outcomes

By studying this course, the students will be able to:

- Describe uses and applications carbohydrates, lipids and heterocycles
- Use the knowledge gained from study of carbohydrates, lipids and heterocycles to propose greener and better synthetic routes.
- Use the chemistry and biology of carbohydrates, lipids and heterocycles to better serve the mankind.

SYLLABUS OF DSC-11

Unit-1: Carbohydrates & Lipids

(Hours: 24)

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; Kiliani-Fischer synthesis and Ruff degradation; Linkage between monosaccharides: Comparative study of the structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch, cellulose and glycogen) excluding their structure elucidation. Reactions of disaccharides-reducing property, hydrolysis, methylation and acetylation.

Lipids: Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Unit-2: Heterocyclic Compounds

(Hours:21)

Classification and nomenclature of heterocyclic compounds (containing only one hetero atom). Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings).

General methods of synthesis for: furan, thiophene, pyrrole (Paal-Knorr synthesis, Hantzsch synthesis), pyridine (Hantzsch synthesis), indole (Fischer Indole synthesis), quinoline (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis)

Properties: Physical properties, discussion on the following reaction (with mechanism) for furan, pyrrole, thiophene, pyridine, indole and quinoline: Electrophilic substitution- nitration, sulphonation, halogenation, formylation, acylation, mercuration and carboxylation. Oxidation, reduction, addition, reactions showing acidic /basic character, reaction with diazonium salts, ring opening, ring expansion and nucleophilic substitution reaction wherever applicable should be discussed.

Practical:

Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Estimation of sugars by using Fehling solution.
2. Functional group tests for amine, nitro and amides.
3. Determination of saponification value of the given oil.
4. Determination of iodine number of the given oil.
5. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (carboxylic acids, carbonyl compounds, carbohydrates and esters) and preparation of one suitable derivative.

Essential/recommended readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), **Biochemistry**, 9th Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.
3. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, 1st Edition, Berlin, Boston: De Gruyter.
6. Finar, I.L., (2012), **Organic Chemistry** Volume 1, 6th Edition, Pearson Education.
7. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

Practical:

1. Vogel, A.I. (2012), **Quantitative Organic Analysis**, Part 3, Pearson Education.
2. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
4. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume—I**, I K International Publishing house Pvt. Ltd, New Delhi
6. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume—II**, I K International Publishing house Pvt. Ltd, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-12 (DSC-12): Electrochemical Cells, Chemical Kinetics and Catalysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
Electrochemical Cells, Chemical Kinetics and Catalysis (DSC-12, Physical Chemistry IV)	04	03	--	01	Class 12 th with Physics, Chemistry, Mathematics	--

Learning Objectives

The Objectives of this course are as follows:

- To provide a detailed understanding about galvanic cells and their types
- To explain the applications of galvanic cells and EMF measurements.
- To get an understanding of the kinetics of simple and complex chemical reactions
- To give basic concept about catalysts and enzymes.
- To teach the working of potentiometer and different electrodes for performing potentiometric titrations
- To explain the experimental study of kinetics of simple reactions

Learning outcomes

By studying this course, the students will be able to:

- Explain the working of electrochemical cells and different types of galvanic cell.
- Devise a spontaneous galvanic cell using various combinations of half-cells.
- Understand the concept of concentration cell
- Use the appropriate galvanic cell to measure pH, calculate thermodynamic parameters and perform potentiometric titrations.
- Write rate law and derive rate equations for simple and complex reactions and understanding of theories of reaction rates.
- Understand different types of catalysts and mechanism of enzyme catalysis.
- Perform potentiometric titrations using appropriate electrodes for quantitative analysis.
- Set up experiments to study the kinetics of simple reactions.

SYLLABUS OF DSC-12

Unit-1: Electrochemical Cells

(Hours: 21)

Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and $\text{SbO}/\text{Sb}_2\text{O}_3$ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Structure of electric double layer (qualitative aspects only).

Unit-2: Chemical Kinetics**(Hours: 18)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods for determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates, introduction to electrode kinetics (qualitative aspects only).

Unit-3: Catalysis:**(Hours: 6)**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical:**Credits: 01****(Laboratory periods: 15 classes of 2 hours each)****(A) Potentiometry:**

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Dibasic acid vs. strong base
4. Mixture of strong and weak acid vs strong base
5. Potassium dichromate vs. Mohr's salt

(B) Chemical Kinetics:

Study the kinetics of the following reactions

1. Iodide-persulphate reaction by Initial rate method
2. Acid hydrolysis of methyl acetate with hydrochloric acid.
3. Saponification of ethyl acetate by conductometric measurements.

Suggested experiments

1. To study the kinetics of Iodide-persulphate reaction using integrated rate method.
2. Comparison of the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.

Essential/recommended readings

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry** Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), **Physical Chemistry**, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 3, 6th Edition, McGraw Hill Education.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 5, 3rd Edition, McGraw Hill Education.
6. Laidler K.J. (2003), **Chemical Kinetics**, 3rd Edition, Pearson Education India.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York

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