

**K.L. University, Vaddeswaram- 522502**  
**M.Sc., Inorganic Chemistry- II, II-Semester, 2016-17**

**Course Handout**

- 1. Course Name** : Inorganic Chemistry
- 2. Course Code** : 16CY 1206
- 3. Course Coordinator** : Prof. Dr. K. Ravindhranath (Theory)
- 4. Course Structure(LTP)** :
- |          |          |          |
|----------|----------|----------|
| <b>L</b> | <b>T</b> | <b>P</b> |
| <b>4</b> | <b>0</b> | <b>6</b> |
- 5. Credits** : 7
- 6. Team Members** : Prof. Dr. J. Shanmuk Kumar (Practicals)
- 7. Course Description(Course Rationale):**

The chemical substances are of two natures: organic and inorganic. The chemistry pertaining to Inorganic aspects of reactions, their mechanisms and their manifestations into different physical and chemical properties, is an essential ingredient for a chemistry student mastering the subject at PG level. (irrespective of specialization). Hence, the present course will provide scope for the student to acquire knowledge in the inorganic aspect of the chemistry and thereby enabling the student to apply the same for his/her pursuits of chemical knowledge.

**8. Course Objectives:**

Provide in-depth knowledge on the principles of Inorganic chemistry pertaining to Metal Cluster Compounds, Organic metallic compounds, Metal Ligand equilibria in solution and Inorganic reaction Mechanisms.

- 9. Course Outcomes (CO):** Upon completion of the course, students are able to:

CO #	CO	BTL
1	Understand the principles behind the formation of metal cluster compounds.	2
2	Explain the synthesis, properties, bonding and structures of $\pi$ -complexes of transition metals,	2
3	Illustrate, the principles behind the Metal Ligand equilibria in solution with respect to the formation, their Kinetic and thermal stability, and determinations.	
4	Explain the features of Inorganic reaction mechanisms	2

## 10. Course outcome Indicators:

CO#	COI-1	COI-2	COI-3
CO-I	Understand the nature of the formation of metal cluster.	Discuss the principal and theory of formation of metal clusters	Application of the metal cluster formations to various synthetic mono, binary, tri and hexa nuclear clusters and also for Zintl ions, Chevrel phases.
CO-II	Understand the principals of Effective atomic number , 16 and 18 electron rules, iso electronic and isolable concepts.	Describe the rules with respect to various metallic carbonyls and metallic nitrosyls and dinitrogen complexes of metals.	Applying the concepts of bonding with respect to metallocenes with special reference to ferrocene
CO-III	Discuss the stepwise and overall formation constants	Explain thermodynamic importance of stability constants. Describe methods of determining stability constants for binary complexes in solution.	Applying the factors affecting stability of complexes to various diverse metal complexes with special emphasis on inert and labile complexes (trans effect) from the view point of Crystal field theory
CO-IV	Discuss and explain the energy profile of a reaction and explain lability in terms of VBT and CFT principles.	Explain the nucleophilic substitution reactions in octahedral complexes in terms of SN1 and SN2 reaction mechanisms, and the evidences supporting them. Explain the inner and outer sphere mechanisms	Application of mechanisms for acid-base hydrolysis reactions, anation, electron transfer reactions of complexes, complementary and non-complementary reactions
CO-V	Expertise the student in the semi-micro qualitative analysis of mixtures containing some interfering radicals and rare cations	Develop ability in the qualitative methods of analysis when the components are at semi-micro levels	Applying the analytical ability in assessing the chemical components qualitatively.

## 11. Program Outcomes (Pos):

PO1. Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.

PO2. Identify, formulate, research literature and solve complex engineering problems reaching sustained conclusions using first principles of mathematics and engineering sciences.

PO3. Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Conduct investigations of complex problems including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO5. Create, select and apply appropriate techniques, resources and modern engineering tools including predictions and modeling, to complex engineering activities, with an understanding of the limitations.

PO6. Function effectively as an individual, and as a member or leader in diverse teams and in multi disciplinary settings.

PO7. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective report and design documentation, make effective presentation, give and receive clear instructions.

PO8. Demonstrate understanding of societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.

PO9. Understand and commit to professional ethics and responsibilities and norms of engineering practice.

PO10. Understand impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.

PO11. Demonstrate a knowledge and understanding of management and business practice, such as risk and change management, and understand their limitations.

PO12. Recognize the need for, and have the ability to engage in independent and lifelong learning.

## 12. Mapping of Course Objectives with Programme Outcomes:

1. Highest

2. Moderate

3. Use

Course Outcome	Programme Outcomes (Pos)											
	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012
CO-I		1	1	1	2	1	2		1		3	1
CO-II		1	1	1	2	1	2		1		3	1
CO-III		1	1	1	2	1	2		1		2	1
CO-IV		2							2			
CO-V			1	1	1	1						

### 13. Time Table:

Day/Time	9.00-9.50	9.50-10.40	10.50-11.40	11.50-12.40	01:00 -04:00
Monday			Prof. K.Ravindhranath		
Tuesday			Prof. K.Ravindhranath		
Wednesday			Prof. K.Ravindhranath		Inorganic Lab Dr JVSK
Thursday	Prof. K.Ravindhranath				Inorganic Lab Dr JVSK
Friday	Prof. K.Ravindhranath				
Saturday					

### 14: SYLLABUS:

#### INORGANIC CHEMISTRY-II

##### UNIT-I

**Metal cluster compounds** - definition – evidences for existence of M-M bonds - conditions favorable for formation of M-M bonds – preparation, structure and bonding of the following metal cluster compounds.

$\text{Re}_2\text{Cl}_8^{2-}$ ,  $\text{Mo}_2\text{Cl}_8^{4-}$ ,  $\text{Re}_2(\text{RCOO})_4\text{X}_2$ ,  $\text{Mo}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$ ,  $\text{Cr}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$ ,  $\text{Cu}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$ ,  $\text{Cr}_2\text{Cl}_9^{3-}$ ,  $\text{Mo}_2\text{Cl}_9^{3-}$ ,  $\text{W}_2\text{Cl}_9^{3-}$ ,  $\text{Re}_3\text{Cl}_9$ ,  $\text{Re}_3\text{Cl}_{12}^{3-}$ ,  $\text{Mo}_6\text{Cl}_8^{4+}$ ,  $\text{Nb}_6\text{X}_{12}^{2+}$  and  $\text{Ta}_6\text{X}_{12}^{2+}$ .

Polyatomic clusters – Zintl ions, Chevrel phases.

##### UNIT-II

**Organometallic compounds** - 16 and 18 electron rules.

Isoelectronic relationship - Synthesis, structure, bonding and reactions of carbon monoxide, dinitrogen and nitric oxide complexes.

Isolobal relationship – H, Cl,  $\text{CH}_3$ ,  $\text{Mn}(\text{CO})_5$ ; S,  $\text{CH}_2$ ,  $\text{Fe}(\text{CO})_4$ ; P, CH,  $\text{Co}(\text{CO})_3$

Synthesis, structure, bonding and reactions of metallocenes with special reference to ferrocene

##### UNIT-III

**Metal Ligand equilibria in solution:**

Step wise and overall formation constants and their interaction – trends in stepwise constants – factors affecting the stability of metal complexes – Pearson's theory of hard and soft acids

and bases (HSAB), chelate effect and its thermodynamic origin, determination of stability constants of complexes – spectrophotometric method and pH –metric method.

Reactivity of metal complexes – inert and labile complexes. Explanation of lability on the basis of valence bond and crystal field theories.

## **UNIT- IV**

### **Inorganic Reaction Mechanisms:**

Substitution reactions of metal complexes – D, Id, Ia and A mechanisms – Ligand replacement reactions of metal complexes – Acid hydrolysis – factors affecting acid hydrolysis – Anation and Base hydrolysis of Cobalt(III) complexes. Ligand displacement reactions of square planar complexes of platinum (II). Factors affecting square planar substitution – trans effect (theories).

Electron transfer reactions of complexes – concept of complementary and non-complementary reactions with examples. Inner and outer sphere mechanisms.

### **Text books:**

1. Advanced Inorganic Chemistry by F.A. Cotton and R.G. Wilkinson, IV Edition, John, John Wiley and Sons, New York, 1980.
2. Inorganic Chemistry by J.E. Huheey, III edition, Harper International Edition, 1983.
3. Organometallic Chemistry-A unified approach by A. Singh and R.C. Mehrotra, Wiley Eastern Ltd.
4. Inorganic Chemistry by Shriver and Atkins, Oxford University Press (1999)
5. Theoretical Inorganic Chemistry, II Edition by M.C. Day and J. Selbin, Affiliated East-West press Pvt. Ltd., New Delhi.
6. Mechanisms of Inorganic reactions in solution by D.Benson, McGraw Hill, London, 1968.
7. Inorganic chemistry by K.F. Purcell and J.C.Kotz, W.B. Saunders company, New York, 1977.

## **CO-V: LAB COMPONENT:**

### **1. Qualitative Analysis:**

Semi- micro analysis of six radical mixtures containing one interfering radical and one less familiar cation each,

Interfering anions :

Oxalate, tartrate, phosphate, chromate.

Less familiar Cations:

Thallium, molybdenum, thorium,  
zirconium, vanadium, uranium.

(Minimum three Mixtures)

### **2. Chromatography.**

Separation of cation and anion by paper chromatography.  
(at least one experiment)

## 14. Self Learning Topics:

Unit	Topic	Source
I	The structure of Metal cluster compounds that are not included in the syllabus	T-1
II	16 and 18 electron rules with respect to various metal complexes	T-1
III	Metal Ligand equilibria for typical compounds which are not included in the syllabus	T-1
IV	Concept of complementary and non-complementary reactions with examples	T-1 and 2

## 15. Session and Lesson plan

S. No	CO	Session	Content and Source	Learning objective, End of the session student will	Teaching Methodology	Faculty Approach	Student Approach	Cognitive level expected
1	I	1	Definition – evidences for existence of M-M bonds	Understand the necessity	Chalk and Oral	Explanation	Listens and participate	Understand
2	I	2	Conditions favorable for formation of M-M bonds	Understand	Chalk and talk	Explanation	Listens and participate	Understand
3	I	3	Preparation, structure and bonding of $\text{Re}_2\text{Cl}_8^{2-}$ , $\text{Mo}_2\text{Cl}_8^{4-}$	Understand	Chalk and talk	Explanation	Listen	Understand
4	I	4	Preparation, structure and bonding of $\text{Re}_2(\text{RCOO})_4\text{X}_2$	Apply and use	Chalk and talk	Explanation	Listen and Practice	Understand And apply
5	I	5	Preparation, structure and bonding of $\text{Mo}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$ , $\text{Cr}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$	Understand	Chalk and talk	Explanation	Listen and Practice	Understand And apply
6	I	6	Preparation, structure and bonding of $\text{Cu}_2(\text{RCOO})_4(\text{H}_2\text{O})_2$ , $\text{Cr}_2\text{Cl}_9^{3-}$ , $\text{Mo}_2\text{Cl}_9^{3-}$ ,	Understand	Chalk and talk	Explanation	Listen and	Understand
7	I	7	Preparation, structure and bonding of $\text{W}_2\text{Cl}_9^{3-}$ , $\text{Re}_3\text{Cl}_9$ , $\text{Re}_3\text{Cl}_{12}^{3-}$ , $\text{Mo}_6\text{Cl}_8^{4-}$	Understand	Chalk and talk	Explanation	Listen	Understand
8	I	8	Preparation, structure and bonding of $\text{Nb}_6\text{X}_{12}^{2+}$ and $\text{Ta}_6\text{X}_{12}^{2+}$ .	Understand	Chalk and talk	Explanation	Listen	Understand
9	I	9	Polyatomic clusters – Zintl ions	Understand	Chalk and talk	Explanation	Listen	Understand
10	I	10	Chevreil phases.	Apply and use	Chalk and talk	Explanation	Listen	Apply and use
11	I	11	Isoelectronic relationship	Apply and use	Chalk and talk	Explanation	Listen and practice	Apply and use

12	I	12	Isolobal relationship – H, Cl, CH <sub>3</sub> , Mn(CO) <sub>5</sub> ; S, CH <sub>2</sub> , Fe(CO) <sub>4</sub> ; P, CH, Co(CO) <sub>3</sub>	Apply and use	Chalk and talk / PPT	Explanation	Listen	Apply and use
13	II	13	Synthesis and properties of various metal carbonyl compounds	Understand	Chalk and talk / PPT	Explanation	Listen and analyze	Understand
14	II	14	Structure, bonding and magnetic properties of metal carbonyl compounds	Understand	Chalk and talk	Explanation	Listen	Understand
15	II	15	Synthesis and properties of nitric oxide complexes of metals	Understand	Chalk and talk	Explanation	Listen	Understand And remember
16	II	16	Structure, bonding and magnetic properties of metal nitrosyl compounds	Understand	Chalk and talk	Explanation	Listen	Understand And remember
17	II	17	Synthesis, properties and structure of dinitrogen compounds of metals	Analyze	Chalk and talk / PPT	Explanation	Listen and practice	Analyze
18	II	18	Synthesis, structure, bonding and reactions of metallocenes	Analyze	Chalk and talk	Explanation	Listen and practice	Analyze
19	II	19	Synthesis, and reactions of ferrocene	Understand, Analyze	Chalk and talk	Explanation	Listen and practice	Understand and Analyze
20	II	20	Structure and bonding of ferrocene from the view point Valence bond theory and Molecular orbital theory	Understand, Analyze	Chalk and talk	Explanation	Listen and practice	Understand and Analyze
21	III	21	Step wise and overall formation constants and their interactions trends in stepwise constants	Understand	Chalk and talk / PPT	Explanation	Listen	Understand
22	III	22	Kinetic Stability Vs thermal stability	Understand	Chalk and talk	Explanation	Listen and practice	Understand and Analyze
23	III	23	Factors affecting the stability of metal complexes	Analyze	Chalk and talk	Explanation	Listen and practice	Analyze
24	III	24	Pearson's theory of hard and soft acids and bases (HSAB)	Analyze	Chalk and talk	Explanation	Listen	Analyze
25	III	25	Chelate effect and its thermodynamic origin.	Apply and use	Chalk and talk / PPT	Explanation	Listen	Apply and use
26	III	26	Determination of stability constants of complexes – Spectrophotometric method	Apply and use	Chalk and talk / PPT	Explanation	Listen	Apply and use
27	III	27	Determination of stability constants using pH –metric method	Understand	Chalk and talk	Explanation	Listen and participate	Understand

28	III	28	Reactivity of metal complexes – inert and labile complexes	Apply and use	Chalk and talk	Explanation	Listen and participate	Apply and use
29	III	29	Explanation of lability on the basis of valence bond	Apply and use	Chalk and talk	Explanation	Listen	Apply and use
30	III	30	Explanation of lability on the basis of crystal field theories	Understand	Chalk and talk	Explanation	Listen and participate	Understand
31	IV	31	Substitution reactions of metal complexes	Understand	Chalk and talk	Explanation	Listen	Understand
32	IV	32	D, Id, Ia and A mechanisms	Understand	Chalk and talk	Explanation	Listen	Understand
33	IV	33	Ligand replacement reactions of metal complexes	Understand	Chalk and talk	Explanation	Listen	Understand
34	IV	34	Acid hydrolysis -factors affecting acid hydrolysis of Cobalt (III) complexes	Understand	Chalk and talk / PPT	Explanation	Listen	Understand
35	IV	35	Anation of Cobalt (III) complexes	Understand	Chalk and talk	Explanation	Listen	Understand
36	IV	36	Factors affecting the base hydrolysis of Cobalt(III) complexes	Understand	Chalk and talk / PPT	Explanation	Listen	Understand
37	IV	37	Ligand displacement reactions of square planar complexes of platinum (II)	Analyze	Chalk and talk	Explanation	Listen	Analyze
38	IV	38	Factors affecting square planar substitution – trans effect (theories).	Understand	Chalk and talk	Explanation	Listen and participate	Understand
39	IV	39	Electron transfer reactions of complexes	Analyze	Chalk and talk	Explanation	Listen	Analyze
40	IV	40	Concept of complementary and non-complementary reactions with examples	Analyze	Chalk and talk	Explanation	Listen	Analyze
41	IV	41	Inner and outer sphere mechanisms	Analyze	Chalk and talk	Explanation	Listen	Analyze



## 16. Evaluation scheme:

### EVALUATION PLAN FOR COURSES (16CY110-organic chemistry)

Evaluation Component	Marks	Weightage	Date	Duration (Hours)	CO 1		CO 2		CO 3		CO 4		CO-5
					1	2	1	2	1	2	1	2	
Course Outcome Indicator Number					1	2	1	2	1	2	1	2	
Blooms Taxonomy Level					1	2	2	2	2	2	1	2	
Assignment Test	20	2.5 %		1 ½	10	10							
Test 1	20	15%*		1 ½			10	10					
Test 2	20			1 ½					10	10			
Home Assignment	20	2.5%		-							10	10	
Quiz	20	2.5%		20 min	5		5		5		5		
Lab	50	12.5%		3 Hrs Continuous Evaluation-15 marks, Viva-vove-10, Test -25. Total marks will be scaled to 5%.									
Attendance	5	5%	----		75% of Theory+25% of lab attendance.								
Semester End Exam	60	35%		3	2	10.5	2	10.5	2	10.5	2	10.5	
	Question Number				3	12	3	12	3	12	3	12	
End-Lab Exam	60	25%			Lab exam will be conducted for 60 marks and scaled to 10%. Initial rubrics for evaluation are: [Record (10) + Write up (10) + Experimentation (25) + Viva-voce(15)].								

\* 75 % of the Best and 25% of other test together will be taken for 20 marks, internal.

#### TEST PATTERN:

- Assignment Test:** 6 Questions will be given in advance and any two questions of the Faculty choice have to be answered.
- TEST1 & 2:** It comprises two sections: **Section-1:** 6 short answer question of 1 mark each are to be answered (no choice). **Section-2:** 2 questions of 7 marks each out of 3 questions have to be answered, totaling to 20 marks. **75 % of the Best and 25% of other test together will be taken for 15 marks, internal.**
- Home Assignment:** Two Questions will be given for 20 marks each and to be submitted on or before submission date announced by the faculty in the class.
- Quiz:** 20 Objective Questions will be given for 20 marks and to be answered in 20 minutes.
- Semester End exam:** Four questions with internal choice 4x15=60

**Chamber consultation hours:** Monday : 12:40 PM- 2:20PM

Saturday : 12:40 PM- 2:20PM

**17. Notices:**

All notices regarding course matters will be displayed in e-learning site & copy of it in department notice board.

**Note:**

- a. Each student is required to attend all classes regularly with calculator and is required to complete all the work assigned for the course.
- b. Instructors of courses are not obligated to provide make-up opportunities for students who are absent, unless the absence has been officially approved. An officially approved absence, however, merely gives the individual who missed the class an opportunity to make up the work and in no way excuses him from the work.
- c. Re conduction of tests will not be entertained, whatever may be the reason. Submission of home assignments after the deadline will not be either accepted or awarded any marks.
- d. All students in the class must treat others with civility and respect and conduct themselves during class sessions in a way that does not unreasonably interfere with the opportunity of other students to learn. Failure to comply with this requirement may result in points being deducted from a student's final numerical average / soft skills.

**18. Signature of the Course Coordinator:****19. Signature of the Group Head:****20. Signature of the HOD:**