



**Department of Chemistry**  
**College of Science**  
**University of Salahaddine**  
**Subject: Inorganic Chemistry (bond theory)**  
**Course Book – 3<sup>rd</sup> Stage-1<sup>st</sup> course**  
**Lecturer's names: M.Sc. Muhammad Haji Khalil**  
**Academic Year: 2023/2024**

# Course Book

1. Course name	Theoretical inorganic chemistry(bond theory)
2. Lecturer in charge	Muhammad Haji Khalil
3. Department/ College	Chemistry/science
4. Contact	<a href="mailto:muhammad.khalil@su.edu.krd">muhammad.khalil@su.edu.krd</a> <a href="mailto:muhammed.haji@ymail.com">muhammed.haji@ymail.com</a>
5. Time (in hours) per week	Theoretical: 2
6. Office hours	Tuesday 9:30-11:30 am
7. Course code	
8. Teacher's academic profile	Obtained B.Sc. in 1999, M.Sc. in 2011
9. Keywords	Inorganic chemistry, coordination compounds.
<b>10. Course overview:</b> <b>What is Inorganic Chemistry?</b> <p>With this lesson, you will learn the definition of inorganic chemistry. You will also learn the types of inorganic compounds, how they react and their applications in several industry sectors. <b>Inorganic chemistry</b> is the study of the <i>formation, synthesis and properties</i> of compounds that do not contain carbon-hydrogen bonds. Chemical substances containing carbon-hydrogen bonds are studied in <b>organic chemistry</b>.</p> <p><b>Importance of chemistry in our daily life:</b></p> <p>The importance of chemistry in daily life is that the elements studied in chemistry are the elements that make up the entire world; everything we touch and see and can sense. The importance of chemistry in daily life is that the elements studied in chemistry are the elements that make up the entire world; everything we touch and see and can sense is a result of chemistry. Because this is true, it is important that we understand how these elements compounds came to be, what they can do, and how they work together, so that we can build upon our knowledge, make new discoveries, and change the way our world comes together.</p> <p>Inorganic chemistry is concerned with the properties and behavior of inorganic compounds, which include metals, minerals, and organometallic compounds. While organic chemistry is defined as the study of carbon-containing compounds and inorganic chemistry is the study of the remaining subset of compounds other than organic compounds, there is overlap between the two fields (such as organometallic compounds, which usually contain a metal or metalloid bonded directly to carbon).</p>	
<b>11. Course objective:</b> <p>This course includes a detailed overview of historical development of coordination chemistry, hypothesis and theories which proposed for interpreting the nature of coordinating bonds between metal ions and ligands, Coordination numbers, Transition metals, VSEPR rule for determination of the shape and geometries of the covalent compounds,</p> <p>The principles governing metal—ligand complex stability and specificity depend on the properties of both the metal ion and the chelating agent, as summarized briefly in the following sections. More comprehensive reviews on ligand design for selective complexation of metal ions in aqueous solution are available. This discussion sets the stage for understanding the properties of the compounds presented throughout this article.</p>	

- 1.They are used in photography, i.e., AgBr forms a soluble complex with sodium thiosulfate in photography.
- 2.K[Ag(CN)<sub>2</sub>] is used for electroplating of silver, and K[Au(CN)<sub>2</sub>] is used for gold plating.
- 3.Some ligands oxidize Co<sup>2+</sup> to Co<sup>3+</sup> ion.
- 4.Ethylenediaminetetraacetic acid (EDTA) is used for estimation of Ca<sup>2+</sup> and Mg<sup>2+</sup> in hard water.
- 5.Silver and gold are extracted by treating zinc with their cyanide complexes.

## 12. Student's obligation

the attendance & completion of all tests assignments and Quiz

## Syllabus of Coordination Chemistry

2 Hours/week (theory) + (practice) 2hours/week

### Practical:

#### Quizzes

In class every week, the students should already have knowledge of subject that they had taken before, and ready for any quizzes.

Reports and Seminar

exams

## 13. Forms of teaching

White Board and data show

## 14. Assessment scheme

Breakdown of overall assessment and examination

The students are required to do two closed examinations at the course besides other assignments, for example daily quizzes and other activities which may held 5% of total grades (5 marks), final examination which bears 50% from the total degrees. Over all degrees 15% theory (2 hours per week) and 35% practical (3 hours per week).

The student is required to achieve one closed exam at the mid of each semester for practical course beside other assignments. For each experiment the students must prepare full text paper which includes theory, calculations, discussion and homework.

The grads are arranged as follows:

Semester exam: 10 %

Class room and assignments 2 %

Absence and Quiz: 3 %

It means 10 % for each semester.

## 15. Student learning outcome:

Preparation complexes and determination their contents and absorbances.

### “Medicinal Applications of Coordination Chemistry”

Inorganic compounds have been used in medicine for thousands of years, often without a known molecular basis for their mechanism of action, and with little attempt to design them. The design of coordination (metal) complexes is not an easy task. The organic chemist often deals with diamagnetic compounds which are both kinetically and thermodynamically stable, and benefits from the use of well-developed speciation techniques, especially <sup>1</sup>H and <sup>13</sup>C nuclear magnetic resonance (NMR) spectroscopy. For

metal compounds the situation is more complicated. Ligand substitution and redox reactions can be facile, can occur over very wide timescales, and are not so easily followed by conventional techniques, especially under physiologically relevant conditions (for instance, at micro molar concentrations). But the challenge is real and worth exploring. We need new drugs with novel mechanisms of action. Inorganic chemistry offers that possibility.

### **Platinum Anticancer Drugs**

Two areas of work have highlighted the potential of inorganic chemistry in recent years: the platinum anticancer field and gadolinium compounds, used as contrast agents in magnetic resonance imaging (MRI). Both of these are well covered in this new book. Platinum commands about forty pages. This is warranted. Platinum compounds are now the world's best-selling anticancer drugs – they have billion-dollar sales each year. If you are not familiar with atomic structure, types of chemical bonds, oxidation states, coordination geometries, isomerism, electronic structure and magnetism, then there are some one hundred pages (just over a quarter of the book) of introduction to help you, including the background on square-planar platinum complexes needed to understand the mechanism of action of the first platinum complex to be approved for clinical use: cisplatin (*cis*-diamminedichloroplatinum (II)).

Inorganic compounds are used as catalysts, pigments, coatings, surfactants, medicines, fuels, and more. They often have high melting points and specific high or low electrical conductivity properties, which make them useful for specific purposes.

## **16. Course Reading List and References**

1. S. Z. Haider, *Advanced Inorganic Chemistry*.
2. James E. Huheey, *Inorganic Chemistry*.
3. Cotton, Wilkinson and Gaus, *Basic Inorganic Chemistry*.
4. Shriver, Atkins and langford, *Inorganic Chemistry*.
5. Douglas. McDaniel and Alexander, *Concepts and Models of Inorganic Chemistry*.
6. Sharpe, *Inorganic Chemistry*.
7. W. L. Jolly, *Inorganic Chemistry*.
8. Purcell and Kotz: *Advanced Inorganic Chemistry*
9. J. E. Huheey: *Inorganic Chemistry*
10. J. D. Lee: *Inorganic Chemistry*
11. M.L. Tobe: *Inorganic Reaction Mechanism*

<p>12. Shriver, Atkins and Langford: Inorganic Chemistry</p> <p>13. Douglas, McDaniels and Alexander: Concepts and Models of Inorganic Chemistry</p> <p>14. Katakis and Gordon: Mechanism of Inorganic Reactions</p>	
<b>17. The Topics:</b>	<b>Lecturer's name</b>
<p><b>An Introduction to Coordination chemistry: (4 weeks)</b></p> <p>1- The Historical Development of Coordination Compounds:  2- Hypothesis and theories proposed for explaining the nature of coordinating bonds.  3- The Blomstrand-Jorgensen Chain Theory.  4- The Werner Coordination Theory.  5- Sidgwick (EAN) rule and Pauling principle of Coordination Bonds.  6- Nomenclature of ligand and coordination complexes (IUPAC) rule.</p> <p><b>Bonding Theories for Coordination Compounds: (3 weeks).</b></p> <p>The Lewis Acid-Base Definition:</p> <p>Valence Bond Theory (VBT):  Coordination number, Hybridization and geometrical structure, Origin of Magnetic properties, weakness points of VBT</p>	<p><b>Muhammad Haji Khalil</b></p>
<b>18. Practical Topics</b>	<b>Lecturer's name</b>
<p>Introduction of Practical inorganic chemistry</p> <p>1-Preparation of tetraamine copper(II)sulphatehydrate <math>[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}</math> .  2-Determination of <math>\text{NH}_3</math> in the complex <math>[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}</math> .  3-Determination of <math>\text{Cu}^{2+}</math> in the complex <math>[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}</math> .  4-Preparation of tris(ethylenediamine)nickel(II) thiosulfate <math>[\text{Ni}(\text{en})_3] \text{S}_2\text{O}_3</math>  5-Experiment No.7: Determination of Nickel(II) in the complex <math>[\text{Ni}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3]\text{S}_2\text{O}_3</math>:  6-Experiment No.6: Preparation of tris(acetylacetonato)iron(III) <math>[\text{Fe}(\text{C}_5\text{H}_7\text{O}_2)_3]</math> :</p>	<p>Lecturer names:  Muhammad Haji Khalil  &amp; Adnan Muhammad Qdir  (2hrs)  13-14/9/2023  20-21/9/2023  27-28/9/2023  4-5/10/2023  11-12/10/2023</p>

7-Sodium aqua(ethylenediaminetetraacetato)ferrate(III)dihydrate.

$\text{Na}[\text{Fe}(\text{EDTA})\text{H}_2\text{O}]\cdot 2\text{H}_2\text{O}$  .

8-Preparation of tris(acetylacetonato)diaqualanthanium(III)[ $\text{La}(\text{C}_5\text{H}_7\text{O}_2)_3(\text{H}_2\text{O})_2$  ]

9- Preparation of tris(acetylacetonato)Manganese(III) [ $\text{Mn}(\text{C}_5\text{H}_7\text{O}_2)_3$ ]:

18-19/10/2023

**References :**

1. Inorganic Experiments by J.Derek Woollins.
2. Inorganic Chemistry by Shriver and Atkins.
3. Inorganic Chemistry by Carthrine E. Housecroft.
4. Basic Inorganic Chemistry by Cotton and Wilkinson.
5. Modern Inorganic Chemistry by Jolly.
6. Modern Inorganic Chemistry by Lagowski.

**19. Examinations:**

Q1/ What's Weakness points of VBT?

Q2/Ex<sup>1</sup> [ $\text{Co}(\text{NH}_3)_6$ ] $\text{Cl}_3$  Calculated EAN of this complex

Atomic number of Co = 27 & Ex2: [ $\text{Ag}(\text{NH}_3)_4$ ] $\text{Cl}$  Ag = 47

Q3/ (a) What is the systematic name of  $\text{Na}_3[\text{AlF}_6]$ ?

(b) What is the systematic name of [ $\text{CoCl}_2(\text{en})_2$ ] $\text{NO}_3$ ?

Q4/(c) What is the formula of tetraamine bromo chloroplatinum (IV) chloride?

(d) What is the formula of hexaamminecobalt (III) hexachloroferrate (III)?

Q5/[ $\text{Ag}(\text{NH}_3)_2$ ] $\text{Cl}$  or [ $\text{Ag}(\text{NH}_3)_2$ ] $\text{NO}_3$ .

In these compounds,

silver is \_\_\_\_\_

$\text{NH}_3$  is \_\_\_\_\_

and  $\text{Cl}^-$  or  $\text{NO}_3^-$  is \_\_\_\_\_.

Ligands are attached by \_\_\_\_\_ bonds

Counterions are attached by \_\_\_\_\_ bonds!

Q6/Explain Blomstrand-Jorgensen theory.

Q7/draw the M.O diagram for  $\text{O}_2$  and  $\text{N}_2$  .

Q8/ percentage absorbance of ( $2.5 \times 10^{-4}\text{M}$ )  $\text{KMnO}_4$  solution is (9%) in (0.1)cm cell at maximum absorption.

1- What is the Molar absorption coefficient?

2- If the concentration was 700 ppm what would be the absorbance?

3- Calculate the transmittance percentage at 700 ppm.

Q9/A-Give reason for the following:

1-In preparation lanthanum complexes always produce high coordination number, why?

2- Addition  $\text{H}_2\text{O}_2$  in preparation of  $[\text{Co}(\text{en})_3]\text{Cl}_3$ , could you use  $\text{KMnO}_4$ , why?

3- Addition of ammonium sulphate  $(\text{NH}_4)_2\text{SO}_4$  for determination  $\text{Cr}^{3+}$  in the complex  $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2] \cdot 2\text{H}_2\text{O}$ .

B-Write the preparation chemical reaction with balancing and hybridization with name geometrical structure for each of the following complexes:

1- cis- $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2] \cdot 2\text{H}_2\text{O}$ .

2-  $[\text{La}(\text{acac})_3(\text{H}_2\text{O})_2]$ .

3-  $[\text{Co}(\text{en})_3]\text{Cl}_3$ .

Q10/ Find the weight percentage of  $\text{NH}_3$ , when (0.2g) of its complex was dissolved in (15ml) of (0.25N)HCl, the excess of HCl was back titrated with 10ml of (0.1N) NaOH using methyl red as indicator.

Q11/ prepare the following complexes with balancing chemical reaction, write the hybridization and draw geometrical structure for each one:

1- Trans-ammoniumdiamminetetranitrocobaltate (III) hydrate.

2- Trisacetylacetonatoiron (III).

Q12/Explain reason for each the following

a-Lanthanide contraction.

b-Addition of NaOH for preparation of tris(acetylacetonate)diaqua Lanthanum(III)

Q13/The I.U.P.A.C. name for  $[\text{Ni}(\text{CN})_4]^{2-}$  is:

a)Tetracyanidonickel (II) ion.

b)Tetracyanidonickel (0) ion.

c)Tetracyanidonickelate (II) ion.

d)Tetracyanidonickelate (0) ion.

Q14/Which of the following complex is diamagnetic?

a) $[\text{Co}(\text{F})_6]^{3-}$

b) $[\text{NiCl}_4]^{2-}$

c) $[\text{Ni}(\text{NH}_3)_6]^{2+}$

d) $[\text{Ni}(\text{CN})_4]^{2-}$

Q15/Which of the following is a tridentate ligand?

a) $\text{NO}_3^-$

b)Oxalate ion

c)Glycinate ion

d)Dien

Q16/How many ions are produced from  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$  in the solution?

- a) 3                      b) 4  
c) 5                      d) 6

Q17/Which of the following complex ion possesses  $dsp^2$  hybridization?

- a)  $[\text{Ni}(\text{CN})_4]^{2-}$                       b)  $[\text{Ni}(\text{CO})_4]$   
c)  $[\text{NiCl}_4]^{2-}$                       d)  $[\text{Ni}(\text{PF}_3)_4]$

**20. Extra notes:**

Here the lecturer shall write any note or comment that is not covered in this template and he/she wishes to enrich the course book with his/her valuable remarks.

**21. Peer review :**

This course book has to be reviewed and signed by a peer. The peer approves the contents of your course book by writing few sentences in this section.

*(A peer is person who has enough knowledge about the subject you are teaching; he/she has to be a professor, assistant professor, a lecturer or an expert in the field of your subject).*