Learning Design for: Copy(1) of Practical Inorganic Chemistry

Context

Topic: Chemistry of cobalt,chromium,iron,nickel,copper and their complexes

Total learning time: 2 hours and 30 minutes

Designed learning time: 30 hours

Size of class: 25

Description: university Diyala,science college,chemistry department
Assistant Lec: Nidal Meteab Khamees
Stage:Third
2025-2024
Two and a half hours per week,18 hours per month ,and 108 hours per academic year

Mode of delivery: Blended

Aims

Explanation and clarification of concepts and basics in practical experiments in coordination chemistry of transition elements and their complexes.

Outcomes

Application: define the coordination chemistry, Chemistry of first transition series elements, Practical experiment in the formation of the first transition series elements (ions of the metals cobalt ,chromium ,iron ,nickel ,and copper)

Teaching-Learning activities

Chemistry of chromium ,Preparation of Pot trisoxalato chromate(III) trihydrate

Read Watch Listen *2 hours and 30 minutes* *25 Students* *Teacher present* *Face to face (not online)*

Explanation and clarification of chromium chemistry, practical application in preparation of Pot trisoxalato chromium(III) trihydrate
time: Two and half hours
Steps of applicable
1- Dissolve 1 g of oxalic acid in 6 ml of distilled water.
2- Add 0.32 g of potassium dichromate to the previous solution in batches, then heat the solution to boiling for five minutes.
3- Add 0.4 g of potassium oxalate to the solution, then heat to boiling for two minutes. Cool the reaction to room temperature.
4- Add 1-2 ml of ethyl alcohol, then cool in a water bath and then in an ice bath. You will notice the formation of blue-green crystals, indicating the formation of a complex. After drying the precipitate, calculate the percentage of the complex formed and the percentage

of chromium metal in the complex.
Discussion Questions:
1- Write the redox equations for the preparation of the above complex.
2- Does the complex hydrolyze? Why ?
3- Is the complex an electrical conductor?
4- What is the behavior of oxalic acid in the experiment?
5- What is the behavior of potassium dichromate in the experiment

Linked resources

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تحضير معقد الكروم/تفاعلات كيميائية/ chromium complex

Preparation of pot.trans-diaquabisoxalatochromate(III) dihydrate Trans-K[Cr(C2O4)2(H2O)2].2H2O

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explanation and practical application of the preparation of potassium-trans dihydrate complex chromium(III) di oxalate dihydrate
Steps of applicable
1. Dissolve 0.5 g of dioxalic acid in the smallest possible amount of boiling distilled water, not exceeding 1 ml. Cover the dissolved oxalic acid solution with a watch glass.
2. Dissolve 0.125 g of potassium dichromate in the smallest possible amount of boiling water, approximately 1 ml.
3. Start adding the dichromate solution dissolved in boiling water in slow, incremental steps to the oxalic acid solution dissolved in distilled water in the first step.
4. Cool the reaction mixture to room temperature and store it for the next week.
5. You will notice the formation of dark green-black crystals. Filter and then wash the crystals formed with ethyl alcohol. Then, calculate the percentage of the complex.

Linked resources

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تحضير معقد الكروم/تفاعلات كيميائية/ chromium complex

https://youtu.be/qqAunXcGo8A?si=QJeiAkr7STKyD6f0

Preparation of pot.cis-diaquabisoxalatochromate (III) dihydrate Cis-K[Cr(C2O4)2(H2O)2].2H2O

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explanation and practical application of the preparation of the complex (pot.cis-diaquabisoxalatochromate (III) dihydrate).
Steps of applicable
1. Mix 0.5 g of potassium dichromate with 0.125 g of dioxalic acid after crushing each of them separately.
2. Add drops to a dry ceramic bowl, then add the mixture you formed in step 1 to the ceramic bowl all at once. Cover the mixture with a watch glass.
3. Place the mixture in the ceramic bowl over low heat. You will notice the release of carbon dioxide gas and the mixture turning into a thick liquid. Heat until dry. You will notice the thick liquid turning into a sticky, black substance.
4. Next, add 3 ml of ethanol to the thick, black liquid while it is hot. Mix the liquid with the ethanol. You will notice the mixture solidify into hardened pieces. Break and flatten the hardened pieces.
5. Collect the precipitate formed by filtration, dry it, and calculate the percentage of precipitate.

Discussion Questions:
1- What is meant by the terms "cis" and "trans"?
2- What type of reaction is used to prepare the two complexes?
3- Write the redox equations for preparing the two complexes.
4- Why is the oxalate solution covered with a bottle when preparing a "trans" complex?
5- Why is the addition of dichromate solution to the oxalate gradual when preparing a "trans" complex?
6- In preparing the "cis" isomer, why is ethyl alcohol added to the reaction mixture?
7- Why is heating over low heat required when preparing the "cis" isomer?
8- Make a comparison based on:
1- Method of preparing the complex
2- Geometric shape
3- Hybridization
4- Nomenclature.

Linked resources

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Preparation of pot.cis-diaquabisoxalatochromate (III) dihydrate Cis trans-K[Cr(C2O4)2(H2O)2].2H2O

chemistry of iron and its complexes,

Read Watch Listen	*2 hours and 30 minutes*	*25 Students*	*Teacher present*	*Face to face (not online)*

Explanation and clarification of the chemistry of iron and its complexes and how to prepare iron complexes practically with practical steps. How to Preparation of pot.trioxalatoferrate (III)trihydrate

Steps of applicable
1- Dissolve 0.5 g of ammoniacal ferrous sulfate in 4 ml of hot water acidified with 0.5 ml of 2 M sulfuric acid.
2- Dissolve 0.35 g of dihydrate oxalic acid in 3 ml of hot distilled water.
3- Add the mixture prepared in step 2 to the mixture prepared in step 1 and mix well. Then, heat the mixture slowly, stirring continuously, until boiling. A yellow precipitate (ferrous oxalate) is formed. Allow the resulting precipitate to cool and collect at the bottom of the container.
4- Pour off the clear liquid, then add 2-4 ml of hot water to the precipitate. Allow the mixture to collect at the bottom of the container. Then, pour off the wash water.
5- Add 3 ml of hot water containing 0.95 g of ferrous oxalate to the resulting yellow precipitate. From ferrous monooxalate.
6- Place the mixture in step 5 in an ice bath and add 1 ml of a 30% hydrogen peroxide solution, stirring continuously.
7- Heat the solution to boiling, then dissolve the (Fe(OH)3) precipitate by adding 10 ml of oxalic acid solution prepared with (1 gm $H_2C_2O_4$ + 30 ml D.W.). Then, add the remainder of the solution drop by drop until all the iron hydroxide dissolves, ensuring that the heating is within the boiling point.
Discussion Questions:
1- Why was ferrous sulfate added to water in this experiment? What type of salt?
2- Why was sulfuric acid added?
3- What is the difference between the complex prepared in this experiment and the salt you used to prepare the complex mentioned above?
4- Why was hot distilled water added in step 4?
5- What is the benefit of adding hydrogen peroxide in step 6?
6- What is the by-product of the complex? How is it disposed of?
7- Why does the solution filter out in step 8 when it is hot?
8- Why was ethyl alcohol added when preparing the complex, and why was a water bath used in the steps that required heating?
9- We store the formed crystals in a dark place. Why?

Linked resources

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Preparation of Pure Sample of Potassium Trioxalatoferrate (III) - MeitY OLabs

Preparation of Pure Sample of Potassium Trioxalatoferrate (III) - MeitY OLabs

Chemistry of cobalt

Read Watch Listen	*2 hours and 30 minutes*	*25 Students*	*Teacher present*	*Face to face (not online)*

Explanation and clarification of the chemistry of cobalt and its complexes, explanation and practical application for preparing the complex (hexaamminecobalt(III)trichloride)

Applicable steps:
1. Dissolve 0.5 g of ammonium chloride in 4 ml of distilled water. Boil the solution.
2. Gradually add 0.75 g of hexaamminecobaltose chloride to the boiling solution, stirring continuously until the cobaltose salt dissolves.
3. 3- Add 0.5g of charcoal to the reaction mixture and cool it in a cold water bath.
4- After the reaction mixture has cooled, add 4ml of concentrated ammonia to it. Then, place the mixture in an ice bath.
5- While the mixture is cooling in the ice bath, gradually add 4ml of 20% hydrogen peroxide. When the addition is complete, heat the solution in a water bath to 60°C, taking care not to exceed this temperature. Stir continuously during the addition for 20 minutes until the pink color disappears.
6- After heating is complete, cool the mixture in an ice bath until the crystals of the complex separate at the bottom of the beaker. Then, filter and save the precipitate until the following week for recrystallization.
7- Recrystallization is carried out by adding 15ml of a solution consisting of (25ml conc HCl + 75ml H2O), then boil the solution. While the solution is boiling, add the complex prepared from the previous week. Continue the process. Heat and stir until all the precipitate dissolves and only the impurities (coal) remain. Then filter the solution while it is hot. Gradually add 2 ml of concentrated hydrochloric acid to the filtrate, then cool the solution in an ice bath.You will notice the separation of golden-colored crystals. Filter the crystals and calculate the percentage of complex formed.
Discussion Questions:
1- Why is charcoal added to the experiment? How is it disposed of?
2- Why is hydrogen peroxide added to the reaction mixture? And why is the addition gradual?
3- Why is the reaction mixture heated in a water bath to 60°C for 20 minutes?
4- Why is hot, dilute, concentrated hydrochloric acid added when preparing the [Co(NH3)6]Cl3 complex?
5- Why is the solution filtered hot in the final step?
6- What is the reagent used to detect chloride ions outside the coordination sphere?

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Chemistry of cobalt

Preparation Penta ammine choro cobalt(III) di chloride

Read Watch Listen	*2 hours and 30 minutes*	*25 Students*	*Teacher present*	*Face to face (not online)*

Explain, clarification and practical application of Preparation Penta ammine choro cobalt(III) di chloride
Applicable steps:
1. Dissolve 0.5 g of hexavalent caprylic chloride in the smallest possible amount of water. A heating step may be necessary if the salt is not completely dissolved. Heat in a water bath, then cool the solution to room temperature.
2. Dissolve 1 g of ammonium chloride in 4 ml of concentrated ammonia.
3. Add the solution prepared in step 2 to the cooled solution prepared in step 1.
4. Add 2 ml of 30% hydrogen peroxide, stirring continuously to complete the oxidation process.
5. Gradually add 1 ml of hydrochloric acid to the mixture and continue adding until the mixture is neutral (pH = 7). The addition may reach approximately 3 ml.
6. Add an additional 1 ml of hydrochloric acid. Heat the mixture to boiling, then cool. You will notice the formation of a purple precipitate. Filter and dry the precipitate.
7. Weigh the resulting precipitate and calculate the percentage of precipitate formed.
8- Detect the presence of chloride ions using silver nitrate. Take a small amount for detection and dissolve it in distilled water until the solution becomes clear. Place the dissolved solution in a test tube and add a few drops of silver nitrate. If a white precipitate forms, this indicates that the chloride ion is outside the coordination sphere. If no precipitate forms, this means that the chloride is inside the coordination sphere.
Discussion Questions:
1- Why was hydrochloric acid added?
2- Compare the two complexes prepared in the previous experiment with the current one.
3- How can we confirm the presence of a chloride ion outside the coordination sphere?

Linked resources

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Chemistry of cobalt

Chemistry of nickel Preparation of hexaamminenickel(II) dichloride

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explanation, illustration and practical application of the preparation of the complex (hexaamminenickel(II) dichloride)
Applicable steps:
1- Dissolve 0.5 g of aqueous nickel chloride in a minimum amount of warm distilled water (1 ml).
2- Add 3 ml of concentrated ammonia, stirring continuously until all the nickel hydroxide formed as a result of this reaction is dissolved, until it turns blue.
3- Add 3 ml of ethanol to the resulting blue solution, then cool the mixture in an ice bath until violet crystals form.
4- Filter and dry the resulting crystals, and calculate the percentage of crystals formed.

Discussion Questions:
1- What is the benefit of using ammonia in this experiment?
2- Why was the nickel salt used to prepare the complex dissolved in the smallest possible amount of water?
3- What is the benefit of adding ethyl alcohol in this experiment?
4- Is the complex an electrical conductor?
5- What types of bonds are present in this complex? State them.
6- What is the oxidation state and coordination number of the complex formed?
7- Why is the product cooled before filtration?
8- What is the magnetic property of this complex?

Linked resources

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Preparation Hexaammine Nickel II Chloride

Chemistry of copper Preparation Tetra ammine copper(II)Sulfate .hyderat

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explain .clarification and practical application of Tetra ammine copper(II)Sulfate .hyderat
Applicable steps
1. Dissolve 0.5g of aqueous copper sulfate in a mixture of 2 ml of ammonia and 2 ml of distilled water.
2. Gradually and slowly add 2 ml of ethyl alcohol to the mixture prepared in the previous step, then allow the solution to stand for ten minutes.
3. Cool the mixture in an ice bath. You will notice the formation of blue crystals, indicating the formation of the desired complex. Wash the resulting blue crystals or precipitate with a mixture of 4 ml of ammonia and 1 ml of ethanol. Dry the precipitate, then calculate the percentage of the complex formed.
Discussion Questions
1. Why is copper classified as one of the first transition elements despite having ten electrons in the d orbital in the outer shell?
2. Why was ethanol added when preparing the complex?
3. What are the hybridization probabilities for the complex, and what are the factors that determine these probabilities?

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Preparation Tetra ammine copper(II)Sulfate .hyderat

Experiment of preparation of copper(II) diiodotidine complex

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Copper(II) diiodo complex preparation experiment
Explanation, clarification, and practical application of the preparation of the copper(II) diiodo complex and the qualitative detection of the copper(II) ion
Applicable steps:
1- Dissolve 0.53 g of potassium iodate in 20 ml of distilled water.
2- Dissolve 0.3 g of aqueous copper nitrate in 5 ml of distilled water.
3- Gradually add the first solution to the second solution with continuous stirring. You will observe the formation of a light blue precipitate.
4- Cool the solution in an ice bath, then filter the resulting blue crystals and wash them with a small amount of distilled water. Dry the resulting crystals and calculate the percentage of the complex formed.
Calculations:
Theoretical weight of the complex = Molecular weight of the complex / Molecular weight of the salt used to prepare the complex.
Percentage of the complex = PraPractical steps for the experiment to prepare a complex (Ammonium oxo bis oxalato vanadyl(IV) dihydrogen)
 dihydctical weight of the complex / Theoretical weight of the complex * 100.
Discussion questions:
1- What is the difference between the terms "Iodate" and "Iodato"?
2- Is the complex an electrical conductor? Explain the reason and the equations.
3- What is the magnetic property of the complex? And why?

Linked resources

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Qualitative detection of copper ion

Experiment of preparing (Transpot -diaquabisoxalatocupperate(II)

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explanation, clarification and practical application of the preparation of (Transpot -diaquabisoxalatocupperate(II)
Applicable steps>
1- Dissolve 0.3 g of hydrated copper sulfate in a glass beaker with a minimum amount of distilled water and heat the mixture using an electric heater until it reaches boiling point.
2- Dissolve 0.37 g of potassium oxalate in another glass beaker with the minimum amount of water.
3- Add the contents of the first glass beaker to the contents of the second glass beaker with continuous stirring.

4- Cool the mixture in an ice bath, then filter the resulting crystals and calculate the percentage.
Discussion Questions
1- The geometric shape of the formed complex is distorted by an octahedral structure. What is this distortion called? State the reason that led to this distortion.
2- What is the magnetic property of the complex?

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Tristhiourea cupper(I) sulphate complex preparation experiment

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Explanation, clarification, and practical application of the experiment for preparing the Tristhiourea cupper(I) sulfate complex.
complex.
Applicable steps>
1. Dissolve 0.25 g of thiourea in 4 ml of hot distilled water, then cool the solution to laboratory temperature.
2. Add 0.25 g of copper sulfate in 4 ml of distilled water. Then, gradually add the solution from this step to the cold solution from step 2, stirring continuously.
3. Cool the mixture with cold water until a yellow oily precipitate separates and adheres to the walls of the glass container. Allow the solution to settle to the bottom of the glass container for a short period, then pour off the aqueous layer and retain the oily precipitate. Sometimes, an oily precipitate does not form, but rather the precipitate clumps together in white aggregates.
4- Add 0.15 g of thiourea dissolved in 2 ml of distilled water to the resulting precipitate, then shake vigorously until the complex crystallizes completely (crystals form upon shaking). Then, filter and dry the precipitate.
5- Weigh the dried precipitate and calculate the percentage of the complex.
Discussion Questions
1- What is the behavior of thiourea in this complex?
2- Explain the redox equations that occurred in this experiment.
3- Why is the bonding not via the amine group present in the thiourea compound and the metal ion?
4- What are the by-products in this compound?
5- Why is the bonding via the sulfur atom, as the manganese atom in the thiourea compound, with the metal ion?

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Tristhiourea cupper(I) sulphate complex preparation experiment

Hard and Soft acid ,Hard and soft bas (Pearson's concept) Complex preparation experiment (Ammonium oxobisoxalato Vanadyl(IV) dihydrate)

Read Watch Listen 2 hours and 30 minutes 25 Students Teacher present Face to face (not online)

Pearson's concept explained (Hard and soft acid and Hard and soft base)
Explanation, clarification and practical application of the experiment of preparing the complex (Ammonium oxobisoxalato Vanadyl(IV) dihydrate)
Steps of applicable:

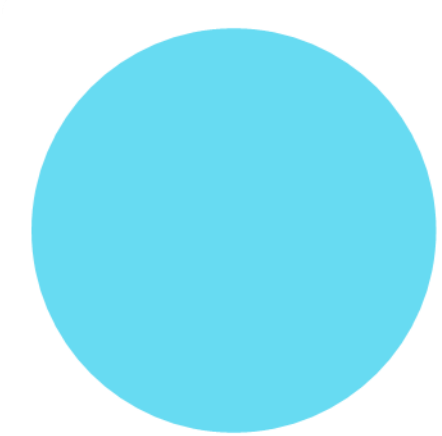
1- Dissolve 1gm of oxalic acid .di hydrate in 5ml of hot distilled water.
2- Add 0.28gm of Ammonium oxalate to solution of mixture of the first step.
3- Add 0.46gm of Ammonium vanadate) NH4VO3(to hot solution as quantities, after completion Ammonium vanadate salt additional ,you will see the mixture is boiling because of release of carbon dioxide gas .Continue until complete reduction.
4- Down the solution to be cool at room temperature then add 10ml of ethanol
5- Down the products to be collect in bottom of beaker for 24h ,after a period you will see oil product had been component, stir the mixture by the glass rode , then flitter the products
6- Add 5ml of ethanol to the filtered product with continuous stirring until an oil product will convert to dark blue crystals after that, filter the component crystals .
7- Put the filter crystals at dark wooden box.

Discussion Questions:
1- Does V (IV) ion obey Pearson's principle? If it obeys Pearson's principle, what does it qualify as considered according to this principle
2- Calculate the weight of the metal ion (V(IV)) in salt and the new complex?
3- In step 3, the reaction is accompanied by a hiss and fizz. What is the reason for this? Citing the chemical equations for this reaction?

Linked resources

- File: Practical Inorganic Chemistry.pdf
- File: Hard and Soft Acids and Bases (HSAB) Principle.pdf
- File: مفهوم بيرسون.pdf

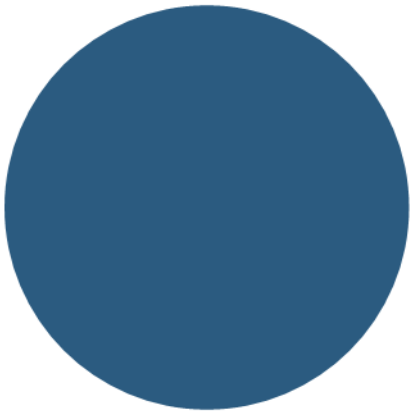
Representations of the learning experience



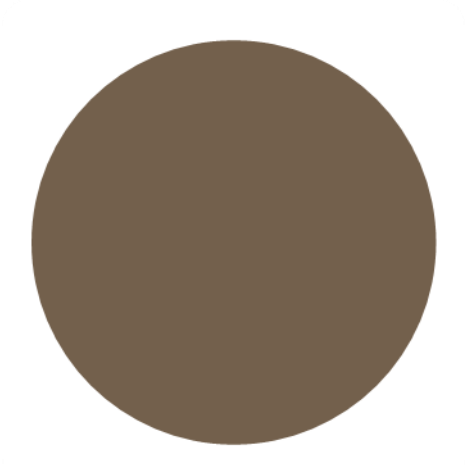
Learning through	minutes	%	
	Acquisition (Read, Watch, Listen)	1800	100
	Investigation	0	0
	Discussion	0	0
	Practice	0	0
	Collaboration	0	0
	Production	0	0



	minutes	%	
	Whole class	1800	100
	Group	0	0
	Individual	0	0



	minutes	%	
	Face to face (not online)	1800	100
	Online	0	0



	minutes	%	
	Teacher present	1800	100
	Teacher not present	0	0