**ESTIMATION OF COBALT CHLORIDE BY COMPLEXOMETRIC TITRATION**

**(6thJUNE 2024-20thJULY 2024)**

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**SUBMITTED BY**

**MITALI RAJ**

**BACHELOR OF TECHNOLOGY,**

**DEPARTMENT OF CHEMICAL ENGINEERING,**

**DR. B.R. AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY, JALANDHAR**

****

**UNDER THE SUPERVISION OF**

**DR. POOJA SRIVASTAVA**

**SCIENTIST ‘E’**

**INSTITUTE OF NUCLEAR MEDICINEAND ALLIED SCIENCES (INMAS)-DRDO**

**BRIG. SK MAZUMDAR MARG, TIMARPUR, NEW DELHI,110054**

**ACKNOWLEDGEMENT**

I extent my heartfelt appreciation to Dr. Pooja Srivastava for her unwavering guidance and support throughout my internship. Her expertise and encouragement have been pivotal in shaping my understanding of the subject matter and refining my skills. The Institute of Nuclear Medicine and Allied Sciences (INMAS) also receives my deepest gratitude, with continual support, whole faculty, forming a treasured part of this dissertation. I am also thankful to Mr. Vinod Kumar Kaushik, Scientist-F, Head CBRN for allowing me to work in his department. I owe my gratitude to Mr. Shubham for constantly guiding me throughout the internship. I am also thankful to Mr. Pankaj for his assistance and support during various stages of this project. I would like to thank my parents for their consistent support and encouragement, throughout my internship. The guidance, encouragement, and assistance from all these individuals have been indispensable in the successful completion of this project. Their unwavering support has not only enriched my knowledge but has also inspired me to grow both professionally. I would like to express my sincere gratitude to my colleagues for their invaluable support and collaboration throughout this project.

**Dr Pooja Srivastava Institute of Nuclear Medicine &Allied**

**Scientist E Sciences**

**Department of Radiological, Defence Research &Development**

**Nuclear and Imaging Science Organisation**

**Phone: 01123905362 Ministry of Defence**

**Government of India**

**Brig. S.K. Mazumdar Marg, Delhi11054**

**CERTIFICATE**

This is to certify that the summer internship report entitled “Estimation of Cobalt Chloride by Complexometric Titration” submitted by Ms. Mitali Raj, student of Bachelors in Technology, Department of Chemical Engineering, Dr. B.R. Ambedkar National Institute of Technology, Jalandhar. This is a record of candidate’s own work carried out by her under my supervision and guidance This report has reached the standard for the submission to the best of my knowledge.

Dr. Pooja Srivastava

(Supervisor)

Scientist E

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1. **ABSTRACT**

Due to high toxicity, heavy metal ions in water pose great risk to the biological system. Therefore, decontamination of water polluted by heavy metal ions attracts significant interest of scientific community. Adsorption by solid adsorbents has been widely used technique for removal of heavy metal ions from water bodies. Solid-wastes generated from industry or anthropogenic activities, and biomass, have been utilized as adsorbents but these wastes modified by nanomaterials have shown improvement in their performance. This report provides an account on the characterization techniques used in the lab and the estimation of heavy metal like cobalt chloride by complexometric titration using different samples prepared in the laboratory.

1. **INTRODUCTION**

Rapid growth of industrialization on one side meets the demand of growing population but on the other side, industrial effluents subjected to water bodies make water contaminated, thus pose serious threat to not only human health but also the environment and natural ecosystems. Contamination of water by toxic heavy metal ions discharged from industries causes severe problem because of their nonbiodegradable, and bio-accumulative nature. Cadmium, Cobalt, barium, Caesium, arsenic, chromium, mercury, and lead are among heavy metals commonly found in these industrial effluents, and beyond their permissible limit in water, exhibit high level of toxicity for both human and animals. [1]

**Cadmium** is a highly toxic metal that accumulates in the body over time, primarily targeting the kidneys and liver. Prolonged exposure to cadmium through ingestion (e.g., contaminated food or water) or inhalation (e.g., tobacco smoke) can lead to serious health issues like kidney damage, lung disorders, and possibly cancer.

**Caesium** is a radioactive heavy metal and can emit harmful gamma radiation. Exposure to radioactive caesium can cause radiation sickness, increase the risk of cancer, and affect the cardiovascular and reproductive systems.

**Barium** and **Cobalt** cause many harmful impacts on human body. Ingestion of large amounts of soluble barium compounds can lead to severe poisoning, causing muscle weakness, abdominal pain, difficulty in breathing, and even cardiac arrhythmias. Inhalation or ingestion of cobalt dust or compounds can lead to respiratory issues, heart problems (cardiomyopathy), and in severe cases, nerve damage.

These elements are harmful due to their toxicity, ability to accumulate in the body, and in some cases, their radioactive nature. Proper handling and control of exposure to these substances are crucial to prevent adverse health effects.

Due to high toxicity, heavy metal ions in water pose great risk to the biological system. Therefore, decontamination of water polluted by heavy metal ions attracts significant interest of researchers. Adsorption by solid adsorbents has been widely used technique for removal of heavy metal ions from water. Solid wastes generated from industry or anthropogenic activities, and biomass, have been utilized as adsorbents but these wastes modified by nanomaterials have shown improvement in their performance. Therefore, modification of wastes by nanomaterials to form composites and application of those composite materials as adsorbent for removal of heavy metal ions is a potential approach for decontamination of water.[2]

In this report we have used several techniques to show the absorbance of heavy metal ion particularly using Cobalt. Some methods are listed below:

1. Complexometric titration
2. UV Spectroscopy
3. Conductometry
4. Atomic Absorption Spectrum

**A. COMPLEXOMETRIC TITRATION**Complexometric titration (also known as Chelatometry) are used mainly to determine metal ions by use of complex -forming reaction. It is a form of volumetric analysis developed after the introduction of the analytical reagent commonly known as an ethylene diamine tetra-acetic acid with di-sodium salt [EDTA], in which the formation of a coloured complex is used to indicate the endpoint of a titration. In this method, a simple ion is transformed into a complex ion and the equivalence point is determined using metal indicators or electrometrically. An indicator is capable of producing an unambiguous change is usually used to detect the endpoint of the titration. The versatility and genal convenience of complexometric titrations are dependent on the correct choice of indicators endpoint detection.[5]

**COMPLEXATION**

The process of complex ion formation is known as complexation. A Complexometric reaction with metal ion involves the replacement of one or more co-ordinate solvent molecules by other nucleophilic groups. These groups bind to the central metal ion known as ligands and in aqueous solution.

In this reaction there is successive replacement of water molecule by ligands groups until the complex is formed. The vast majority of complexometric titration are carried out using multidentate ligands such as EDTA. [1]

**CHELATE**

It is the complex that is formed by the combination of polyvalent metal ions with a molecule which essentially contains two or more groups that can donate electrons. These rings are generally more water soluble chelates. They are the sequestering agents. EDTA is one of the examples of chelating agent.

**LIGANDS**

Complexing agents in any donation ion or molecules are called as ligands that have ability to form one or more covalent bonds with the metal ion. They can be any electron donating group that has the ability to bind with the metal ion producing a complexion ion.

**TYPES OF TITRATION**

1. Direct Titration
2. Indirect Titration
3. Replacement Titration
4. Alkalimetric Titration

The most commonly used titration is direct titration.

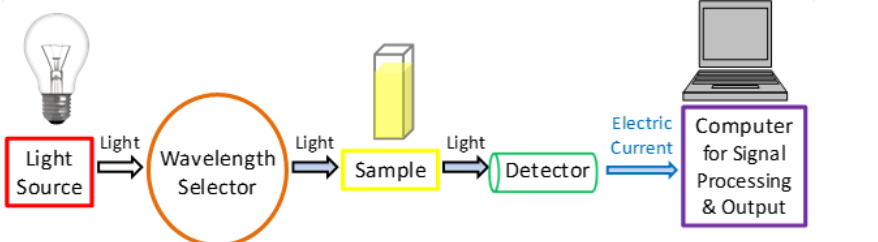
1. DIRECT TITRATION: It is a simple and most convenient method in EDTA titrations. The solution containing the metallic salts is buffered to the desired pH and directly titrated with EDTA standard solution by using suitable pH indicators until the colour change is absorbed. It may be necessary to prevent precipitation of the hydroxide of the metal by addition of sum auxiliary. A black titration may be performed by omitting the sample as the check on the metallic impurities present on the reagent. Metals such as Caesium, barium, zinc, Cobalt directly estimated by direct titration method. [5]
2. INDIRECT TITRATION: Indirect titration is a type of titration in analytical chemistry where the concentration of an analyte is determined by titrating it with a reagent that reacts with the analyte to form a different compound. The endpoint of the titration is determined by a secondary reaction or an indicator, rather than directly observing a change in the analyte itself. In indirect titrations, the reaction between the analyte and the titrant is used to form a product that can be quantitatively measured or detected, allowing the concentration of the analyte to be calculated indirectly. This method is often used when the analyte does not have a suitable endpoint for direct titration or when the reaction between the analyte and the titrant is slow or difficult to observe directly. Indirect titrations are commonly used in complexometric and precipitation titrations, among other types of titrations. These titrations require careful consideration of the stoichiometry of the reactions involved and the choice of indicators or methods to determine the endpoint accurately.[5]
3. REPLACEMENT TITRATION: It is used when direct titration or back titration don’t give sharp endpoint. This analyte (containing metal) is added to the metal-EDTA complex. The metal present in the analyte displaces another metal from the metal-EDTA complex. For example: Mg is displaced by Mn from the Mg EDTA solution. This free Mg metal undergoes direct titration along with a standard EDTA solution. This method requires the addition of an excess quantity of Mg EDTA to the Mn solution.
4. ALKALIMETRIC TITRATION: It is a method of measuring the base concentration of a solution using an acid standard solution. This type of titration is most frequently used. It is a class of titration that involve the determination of acidity or alkalinity in a solution using a strong acid or strong base as the titrant.

**B. UV- SPECTROSCOPY**

UV-spectroscopy is an analytical technique that measures the number of discrete wavelengths of UV or visible light that are absorbed by or transmitted through a sample in comparison to a reference or blank sample. This property is influenced by the sample composition, potentially providing information on what is in the sample and at what concentration. [3]

**WORKING PRINCIPLE**

UV spectroscopy is based on the principle that molecules absorb light in the UV or visible region of the electromagnetic spectrum. The absorption occurs when the energy of the photons matches the energy gap between the electronic states of the molecule.



**LIGHT SOURCE**

As a light-based technique, a steady source able to emit light across a wide range of wavelengths is essential. A single xenon lamp is commonly used as a high intensity light source for both UV and visible ranges. For instruments employing two lamps, a tungsten or halogen lamp is commonly used for visible light.As two different light sources are needed to scan both the UV and visible wavelengths, the light source in the instrument must switch during measurement.

**WAVELENGHT SELECTION**

In the next step, certain wavelengths of light suited to the sample type and analyte for detection must be selected for sample examination from the broad wavelengths emitted by the light source. Available methods for this include:

**Monochromators** - A monochromator separates light into a narrow band of wavelengths. It is most often based on diffraction gratings that can be rotated to choose incoming and reflected angles to select the desired wavelength of light.

* Absorption filters - Absorption filters are commonly made of colored glass or plastic designed to absorb particular wavelengths of light.
* Interference filters - Also called dichroic filters, these commonly used filters are made of many layers of dielectric material where interference occurs between the thin layers of materials. These filters can be used to eliminate undesirable wavelengths by destructive interference, thus acting as a wavelength selector.
* Cutoff filters - Cutoff filters allow light either below (short pass) or above (long pass) a certain wavelength to pass through. These are commonly implemented using interference filters.
* Bandpass filters -Bandpass filters allow a range of wavelengths to pass through that can be implemented by combining short pass and long pass filters together.

**SAMPLE ANALYSIS**

Whichever wavelength selector is used in the spectrophotometer, the light then passes through a sample. For all analyses, measuring a reference sample, often referred to as the "blank sample".  If an aqueous buffered solution containing the sample is used for measurements, then the aqueous buffered solution without the substance of interest is used as the reference.

**DETECTION**

After the light has passed through the sample, a detector is used to convert the light into a readable electronic signal. Generally, detectors are based on photoelectric coatings or semiconductors. After the electric current is generated from whichever detector was used, the signal is then recognized and output to a computer or screen.

**C. CONDUCTOMETER**

A conductometer is an instrument used to measure the electrical conductivity of a substance, usually a liquid or a solution. It determines how well the substance can conduct electricity, which can provide valuable information about its properties and composition. It indicates how easily an electrical charge or heat passes through a material. This piece of equipment primarily measures the conductance of a solution, which is reciprocal of resistance. In simpler term, conductance is the measure of how easily charge or heat can pass through a material. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity.

**PRINCIPLE**

Conductometer works on the principle of electrical conductivity which is the ability of a substance to conduct an electric current. The conductometer measures this by applying a voltage between two electrodes immersed in the solution. It works by sending a current between two electrodes submerged in a solution, with conductance directly proportional to ionic concentration. The current flowing between the electrodes is measured, and the conductometer calculates the conductivity based on the voltage applied and the current measured

**COMPONENT**

* Electrodes: Usually made of platinum or another inert material, they are placed in the solution to complete the circuit.
* Measurement Cell: Holds the solution and the electrodes in a controlled environment.
* Electronic Circuitry: Applies the voltage, measures the current, and processes the data to display the conductivity**.**

**D. ATOMIC ABSORPTION SPECTROMETRY**

Atomic absorption spectrometry (AAS) detects elements in either liquid or solid samples through the application of characteristic wavelengths of electromagnetic radiation from a light source. Individual elements will absorb wavelengths differently, and these absorbances are measured against standards. In effect, AAS takes advantage of the different radiation In AAS, analytes are first atomized so that their characteristic wavelengths are emitted and recorded. Then, during excitation, electrons move up one energy level in their respective atoms (figure 1) when those atoms absorb a specific energy. This energy corresponds to a specific wavelength that is characteristic of the element. Depending on the light wavelength and its intensity, specific elements can be detected and their concentrations measured. [6]

As electrons return to their original energy state, they emit energy in the form of light

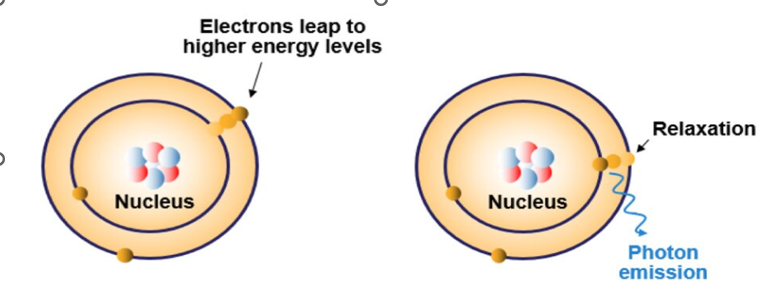


Figure 1: Excitation of an atom & relaxation and photon emission of an atom. (From: ThermoFisher SCIENTIFIC, with permission)

**HANDS ON OTHER INSTRUMENTS**To gain exposure handling and observing of various lab equipment and instrumentation was done.

1. **RHEOMETER**

Rheology is defined as the study of the flow and deformation of matter, which is primarily focusing on the behaviour of complex fluids and soft solids under applied forces. This field includes a wide range of materials, including liquids, polymers, gels, pastes, and biological tissues. Rheological properties describe how these materials respond to stress, strain, angular frequency and time, providing insights into their viscosity (resistance to flow), elasticity (ability to return to original shape after deformation), and viscoelasticity (a combination of viscous and elastic behaviour). Rheology is important in many industrial sectors such as food, pharmaceuticals, cosmetics, and materials science, for understanding and optimizing the processing and performance of products.

It integrates concepts from fluid mechanics to understand how materials respond to applied forces, either by flowing or by deforming. Rheology is an active area of research with developments in understanding how microscopic structures and interactions in materials give rise to macroscopic properties. Innovations in this field can lead to new materials with tailored properties for specific applications.

Understanding rheology is crucial for designing and optimizing products and processes across a wide range of industries, making it a fundamental aspect of materials science and engineering.

RHEOLOGICAL MEASUREMENTS

The rheometer has 3 section, lower part is temperature control chamber which maintains the temperature of the bottom plate and the liquid specimen at a fixed temperature. The upper part has the motor to rotate the top plate which is in the form of cone to which we connect the shaft of different radius. It also has a torque transducer which measures the torque applied when the cone is rotated at a fixed rpm.

The next part is a software that control the motor and other electronic that measures the strain, stress, frequency, data, temperature sensors from the top transducer.

The air bearing is supplied using a compressor. It has machine for setting the temperature of the plate in the viscometer.

**APPLICATIONS OF RHEOLOGY**

**Food Industry**: Rheology plays crucial role in the food industry by controlling the textures and mouthfeel of the food product. For example: the viscosity of sauce, dressing, and syrup is adjusted to achieve desired pouring or spreading characteristics.

It helps in controlling the stability of emulsions by manipulating viscosity and elasticity which helps manufacturers to prevent phase separation and maintain product consistency.

In baking we majorly look into the viscoelastic properties of dough which determine its ability to rise and hold its shape. Rheological testing is used for quality control purposes to ensure consistency and stability of food product.

In dairy products we majorly focus on viscosity and elasticity of product like cheese, yogurt.

**Cosmetics**: Rheology plays a significant role in the formulation, production, and performance of cosmetic products. Rheological properties help in controlling the texture and spread ability of creams, lotions, and gels. By adjusting viscosity and elasticity, manufacturers can achieve desired application characteristics, such as smoothness, easy spread ability, and non-greasiness.

It plays an important role in ensuring the stability of cosmetic formulations, preventing phase separation, sedimentation, or creaming. Rheological measurements are used to assess the performance of cosmetic products, such as their ability to adhere to the skin, withstand environmental stresses, and provide desired sensory attributes (e.g., softness, firmness, matte or glossy finish).

Understanding the flow behaviour under different shear conditions ensures smooth dispensing. Products with pleasing texture, spread ability, and skin feel are more likely to be preferred by consumers, contributing to brand loyalty and market success.

**Material science**: It is a versatile field that involve a major role in rheology including various material.

**Polymer and plastics**: Understanding the viscosity of polymers during processing (e.g., extrusion, injection moulding) is essential for producing high-quality plastic products.

Investigating the melt behaviour of polymers helps in optimizing the manufacturing process and improving the mechanical properties of the final product.

**Construction material**: Rheology is used to study the flow and setting behaviour of cementitious materials, ensuring proper workability and strength.

Understanding the rheological properties of asphalt is essential for designing durable and high-performance pavements.

**Biomedical material**: Rheological properties of hydrogels are crucial for their use in drug delivery systems and tissue scaffolds. Studying the rheology of bio lubricants helps in developing materials for joint lubrication and other biomedical applications.

**Coating and paint**: Rheology affects the application properties of coatings, such as brush ability, rollability, and spray ability. The flow behaviour of coatings during drying and curing impacts the final film's uniformity and appearance.

1. **SONICATOR**

Sonicators known as high-frequency devices (20 kHz) that use ultrasonic energy to agitate particles in liquids. These devices are employed to facilitate a wide variety of processes, such as mixing, cleaning, degassing, cell disruption, and sample preparation.



**Figure 1**: Probe Sonicator **Figure 2**: Bath Sonicator used in laboratory

When sound travels through air, solids, and liquids in the form of sound waves, sound energy is manifested as vibration, with sound waves with higher frequency causing more vibrations. Vibrations in solutions, on the other hand, lead to cavitation – or the formation of vacuum bubbles – which allows Sonicator to facilitate dissolution, homogenization, milling, cell lysis, chemical reactions, degassing, deagglomeration, and cleaning**.**

**PRINCIPLE**

Sonicator works on the principle of ultrasonic sound waves in which cavitation leads to dispersion, homogenization, disintegration, emulsion, extraction, and Sono-chemical effects of the liquids. Due to the application of high-power ultrasound to the liquid which creates regions of high pressure and low pressure. The creation of these regions is dependent on the rate of frequency at which the ultrasound is applied.

When low pressure is applied to the liquid, high-intensity ultrasonic waves are produced, creating small vacuum bubbles in the liquid. As the bubbles reach their saturation level, they collapse and this happens in the high-pressure cycle. This process is termed as cavitation.

**WORKING OF SONICATION:**

The sonication process uses ultrasonic sound waves. During the process, there is a production of thousands of microscopic vacuum bubbles in the solution due to applied pressure. The formed bubbles collapse into the solution during the process of cavitation.

The collapsing of bubbles takes place in the cavitation field leading to the generation of enormous energy as there is a production of waves. This results in the disruption of the molecular interactions between the molecules of water. As there is a reduction in the molecular interactions, the particles start to separate and allow the mixing process to take place.[8]

There is a release of energy from the sound waves that result in friction in the solution. Ice cubes are used during and after the sonication process to prevent the sample from heating up.

Uses of Sonication

The following are the uses of sonication:

* The sonication mechanism is used in ultrasonic cleaning which includes cleaning of particles that adhere to the surfaces.
* It is used in laboratories for cleaning fragile objects such as spectacles and jewellery.
* The artificial ageing of liquors and other alcoholic beverages is done by the process of sonication.
* Other applications of sonication in food industries include dispersions of emulgators and speeding the filtration process.

1. **pH METER**

pH is a unit which measures the acidity or alkalinity of a solution using logarithmic scale with seven as neutral, where low value is more acidic and higher values are more basic is known as pH. A pH meter is statistical device that monitor the hydrogen-ions activity in water- based solution, determining its acidity or alkalinity represented as pH. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter". The difference in electrical potential relates to the acidity or pH of the solution. Testing of pH via pH meters (**pH-metry**) is used in many applications ranging from laboratory experimentation to quality control. [7]



**Figure:** pH meter used in laboratory

**PRINCIPLE**

Ph meter works on the principle of measuring the voltage between two electrodes and display the result converted into the corresponding pH value. It usually has a glass electrode and a reference electrode or a combination electrode.  The electrodes, or probes, are inserted into the solution to be tested.

The design of the electrodes is the key part: These are rod-like structures usually made of glass, with a bulb containing the sensor at the bottom. The glass electrode for measuring the pH has a glass bulb specifically designed to be selective to hydrogen-ion concentration. On immersion in the solution to be tested, hydrogen ions in the test solution exchange for other positively charged ions on the glass bulb, creating an electrochemical potential across the bulb. The electronic amplifier detects the difference in electrical potential between the two electrodes generated in the measurement and converts the potential difference to pH units.

The reference electrode is insensitive to the pH of the solution, being composed of a metallic conductor, which connects to the display. This conductor is immersed in an electrolyte solution, typically potassium chloride, which comes into contact with the test solution through a porous ceramic membrane. The display consists of a voltmeter, which displays voltage in units of pH.

1. **LYOPHILIZER**

Sublimation is the main part of the lyophilizer process where the water content is removed from the product by directly converting the solid state to the vapour state without going for the liquid phase. The material first gets froze because of less temperature and once the material got froze then water content is removed by the vacuum pressure, once the sublimation complete then original dry and solid content are remaining behind in a form of cake, the driving force for water removal during the lyophilization process is the conc. Gradient of water vapour throughout the drying front and the condenser. Water sublimates at the specified pressure and temperature below the triple point (0.0098oC). The solid, liquid, and gaseous state co-exist at the same temperature and pressure that point is known as triple point. [4]

Application include:- This can be used in the purification of samples, this is very useful instrument for the solvent recovery, purification of plant extract and essential oils from nature product, and the distillation of complex mixtures.

**4. OBJECTIVES**

1. To gain lab exposure/hands on experience by learning about lab equipment.
2. To study the estimation of Cobalt Chloride by complexometric titration using different test samples provided by the laboratory.

**5.MATERIALS AND METHODS**

**MATERIALS:-** Cobalt chloride (Make Sigma), Distilled water (Milli Q), Ethylenediamine tetra acetic acid (Make SRL), Eriochrome Black T (Make CDH), burette, beakers, conical flask, weighing machine, buffer of pH 10 & six samples given by the laboratory to test(S1,S2, S3, S4 ,S5 & S6)

**Preparation of 0.01 M EDTA:**

A solution of 0.01M EDTA is prepared by dissolving 1.861g of reagent grade ethylenediaminetetraacetic acid in 500 mL deionized water. NaOH was also added to the solution. **Preparation of buffer solution of pH 10:** 0.259g of borax was taken in 50ml of distilled water to make 0.025M solution and then 18.3 ml of 0.1M NaOH was added into the solution with stirring for 24 h.

**0.003 M Stock solution of Cobalt Chloride:**

For preparing the 0.003 M stock solution 0.195 g CoCl2 was added in 500 ml distilled water with stirring for few minutes.

**THEORY:-** The quantitative determination of many metal ions in solution can be achieved by titrating with a standard solution of a Lewis base (ligand). A necessary requirement is that the ligand combines (complexes) quantitatively with a particular metal ion under the solution conditions. The most common ligand is the anion of ethylenediaminetetraacetic acid (EDTA). The titrant is usually prepared by dissolving the disodium salt of this acid, Na2H2Y, since the acid is only slightly soluble in water.The reaction of cobalt ion with fully ionized EDTA (Y4-) can be represented by the equation:

Co2+(aq) + Y4-(aq) CoY2-(aq)

The end point of the titration can be obtained by observing the colour change of a suitable indicator. In complexometric titrations, the indicator (In) must also act as a ligand toward the metal ion to be determined. The end point occurs as the colour of the indicator changes from its complexed form (CoIn2+) to its un-complexed form (In) when the EDTA titrant combines with the last bit of metal ion in solution. In this experiment, this can be represented by the equation:

CoIn2+ (aq) + Y4-(aq) 6 CoY2-(aq) + In(aq)

(violet) (pink)

**PROCEDURE:**

1. 10 ml standard solution of Co2+ was taken in 7 labelled beakers, 0.02g of samples S1, S2, S3, S4, S5, and S6 (given by the lab) was placed into 6 different 10 ml solution of CoCl2 and one beaker without sample was taken as control (S0). The solutions were kept for 24 h and further tested to observe the absorption capacity of the samples using complexometric titration.
2. The conical flask was taken and 10 ml of standard solution was added into it, followed by 5 ml of buffer maintained at pH 10. The pH of the buffer was checked using a pH meter. A pinch of EBT as an indicator was added into the conical flask, and the endpoint was observed by noting the colour change, which appeared pink.
3. The apparatus was set up, and the burette was prepared with EDTA solution. The conical flask was taken, and the knob of the indicator was opened. EDTA was added dropwise into the flask. The reading at which the solution started changing colour, also known as the end point, was noted. The end point was a sudden colour change from pink to violet.
4. The 6 solutions (S1, S2, S3, S4, S5 and S6) were taken into different flasks, and the same procedure as explained above was repeated for each one respectively.
5. The molarity of the unknown solutions was calculated, followed by calculating their resultant strength.

* **6.EXPERIMENTAL OBSERVATION AND CALCULATIONS**CALCULATIONS:

By using the formula **M1V1=M2V2** we found the molarity of the solutions obtained after adsorption.

For the control (S0) we have:

(M1 x V1) EDTA = (M2 x V2) CoCl2

* 1. x 3.1 ml =M2 x 10 ml

On calculation, we have M2 as 0.003M which is same as prepared concentration.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Samples** | **M1 (EDTA)** | **V1(ml) EDTA** | **M2(Control CoCl2)** | **V2(ml) COCl2** |
| **Control** | 0.01 | 3.1 | 0.003 | 10 |
| **Samples** | **M1 (EDTA)** | **V1 (ml)** | **M2 (Unknown CoCl2)** | **V2 (ml) COCl2** |
| **S1** | 0.01 | 0.8 | 0.0008 | 10 |
| **S2** | 0.01 | 1.5 | 0.0015 | 10 |
| **S3** | 0.01 | 1.5 | 0.0015 | 10 |
| **S4** | 0.01 | 2.5 | 0.0025 | 10 |
| **S5** | 0.01 | 1.3 | 0.0013 | 10 |
| **S6** | 0.01 | 1.9 | 0.0019 | 10 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Samples** | **Molarity of Standard CoCl2 before titration** | **Molarity of CoCl2 after titration** | **-** | **-** |
| **Control (S0)** | 0.003 | 0.003 | Without Sample |  |
| **Samples** | **Molarity of Standard CoCl2 before titration (Qty ~ 10 ml)** | **Molarity of unknown CoCl2 after adsorption by samples**  **(Qty ~ 10 ml)** | **Difference in Molarity (After adsorption -Before Adsorption)** | **Amount of CoCl2 Adsorbed by Samples (g)** |
| **S1** | 0.003 | 0.0008 | 0.0022 | 0.002856 |
| **S2** | 0.003 | 0.0015 | 0.0015 | 0.001947 |
| **S3** | 0.003 | 0.0015 | 0.0015 | 0.001947 |
| **S4** | 0.003 | 0.0025 | 0.0005 | 0.000649 |
| **S5** | 0.003 | 0.0013 | 0.0017 | 0.002207 |
| **S6** | 0.003 | 0.0019 | 0.0011 | 0.001428 |

0.02 g of S1, S2, S3, S4, S5, S6 was taken for the quantification of the Cobalt and 0.0038949 g of CoCl2 was expected in 10 ml of analyte solution initially taken under observation, thus efficiency for respective sample S1, S2, S3, S4, S5, S6 as illustrated below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Samples** | **Amount of CoCl2 initially in the 10 ml solution (g)** | **Amount of CoCl2 Adsorbed per 0.02 g sample** | **Amount of CoCl2 remaining in the 10 ml solution (g)** | **Percentage of CoCl2 remaining in solution** | **Percentage of CoCl2 adsorbed by samples.** |
| **S1** | 0.003895 | 0.002856 | 0.001039 | 26.68 % | 73.32 % |
| **S2** | 0.003895 | 0.001947 | 0.001948 | 50.01 % | 49.99% |
| **S3** | 0.003895 | 0.001947 | 0.001948 | 50.01 % | 49.99 % |
| **S4** | 0.003895 | 0.000649 | 0.003246 | 83.34 % | 16.66 % |
| **S5** | 0.003895 | 0.002207 | 0.001688 | 43.34 % | 56.66 % |
| **S6** | 0.003895 | 0.001428 | 0.002467 | 63.34 % | 36.66 % |

From the above results, we observed that sample S1 has the maximum efficiency for cobalt adsorption with 73.32 % efficiency.

|  |  |  |  |
| --- | --- | --- | --- |
| **Samples** | **Amount of CoCl2 remaining in the 10 ml solution (g)** | **Percentage of CoCl2 adsorbed by samples.** | **Amount of CoCl2 Adsorbed by Samples per gram (or 1000 mg)** |
| **S1** | 0.001039 | 73.32 % | 142.80 mg/g sample |
| **S2** | 0.001948 | 49.99 % | 97.35 mg/g sample |
| **S3** | 0.001948 | 49.99 % | 97.35 mg/g sample |
| **S4** | 0.003246 | 16.66 % | 32.45 mg/g sample |
| **S5** | 0.001688 | 56.66% | 110.35 mg/g sample |
| **S6** | 0.002467 | 36.66 % | * 1. mg/g sample |

**7.RESULTS**

From the above observation, it was found that sample S1 was the best among all the samples, absorbing cobalt chloride very effectively with an efficiency of 73.32% and adsorbing 142.80 mg of cobalt chloride per gram of sample. The molarity of the solution after adding S1 was 0.0008 M, compared to the stock solution's concentration of 0.0031 M. Initially, 0.003895 g of cobalt chloride was present in a 10 ml analytical solution. Upon adding the S1 sample, 0.002856 g of CoCl2 was adsorbed, leaving 0.001039 g of CoCl2 remaining in the solution. The second-best results were obtained for S5, with an efficiency of 56.66%.

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**8.CONCLUSION**

The purpose of this experiment was to determine the decontamination of the heavy metal ions from the waste coming out from the industries. Water contamination caused by heavy metals is significant problem that affect both human and animals. Heavy metal ions can cause severe health problem such as liver and kidney damage, skin disorders, cognitive impairment and even cancer. In this report we have studied about the estimation of Cobalt Chloride by complexometric titration using different samples. The results indicated that the sample S1 is capable of absorbing almost 73.32 % of the cobalt making it the most effective sample among all. The finding suggest that the complexometric titration is effective in estimating strength of the solution. That shows it can be used as a solution to decontaminate waste containing heavy metals like Cobalt.

Future directions in decontamination for heavy metals like cobalt would lie in capability enhancement in several key atheistic areas, precisely toward enhancing efficiency, sustainability, and cost-effectiveness. Soon, heavy metal decontamination will probably proceed on a multidisciplinary basis, fractionalizing in advances in biotechnology, material sciences, nanotechnology, and environmental engineering. Such new developments certainly will not just guarantee more effective measures to address Cobalt and other hazardous heavy metal pollutants but will also design more sustainable and economically viable solutions for contamination mitigation with regard to human health and the environment.

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