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Abstract:

In this study the aim was to determine which way of determining lead dissolved in water is the most efficient way to use. As I am involved with heavy metals as my hobby requires it to be I am interested in how much lead there really is in water and for this I needed an efficient way. My teacher and I decided on using two methods which are, Gravimetric Method and Complexometric Back Titration Method. The reason why Gravimetric Method was selected was that it could be used in nature and is an effective way of neutralizing lead dissolved in water and the reason why Complexometric Back Titration Method was selected is because EDTA is used for Chelation therapy, a method that is used to remove too much lead in blood flow of a living being. With these two methods, we have two ways of determining lead dissolved in water, and each method are useful for two parts of our lives Gravimetric Method the nature and Complexometric Back Titration Method for human health which are really important as it addresses more than one Topic in this case: Nature and human health. As a result of the experiment I found out that Gravimetric Method is far more efficient than Complexometric Back Titration Method. Gravimetric Method is simpler and shorter than Complexometric back Titration Method thus, less error to occur during making of the experiments.

DETERMINATION of Pb^{2+} IONS in SAMPLE WATER

1. INTRODUCTION:

My all-time favourite hobby is miniature model kit making as a result of my hobby I work with paints involving heavy metals that is a need especially in detailed painting. Lead in paint is an ingredient needed for detailed painting but really makes the job longer and messier, paint get on my skin and sometimes I might inhale paint, resulting in higher ratio of heavy metals in my blood stream which shouldn't even exist as it is known that lead in our blood steam is very harmful. Painting, base paint and applying over-coat which is mostly a heavy mixture including heavy metals, as well as weathering the model kit involves a lot of mixtures involving heavy metals in it which is extremely harmful to human health and later with wastes nature.

Heavy metals are extremely harmful to the human health and nature. With heavy metals used in paint as it makes a cheaper product and more reliable paint type for miniature model kit painting which is heavily influenced in their paint by using heavy metals as an example: paints involving heavy metals, do not collect dust and do not corrode in short time making it a very good choice for painting miniature metal, plastic models. However, heavy metals do mix up with our blood stream and will increase the heavy metal ratio that shouldn't even exist. Even though there is a normal considered level as lead is everywhere in nature and can be found anywhere but it is harmful to human health and nature.

Heavy metals are a big problem for painters and model kit makers as it will mix up in their blood flow. Though heavy metals make the paint cheaper and more reliable as lead makes the paint mixture denser and staying. Lead based paints are extremely dangerous and harmful to human health and to environment. Heavy metals being prone to mix up in our blood stream, there should be a way to separate or precipitate them from water and if needed from our blood

stream. From water, precipitation will be effective and from blood, EDTA will be a viable chemical of choice to use as it is not harmful to us like heavy metals themselves. If we can form a complex which can be a stable compound with a heavy metal using EDTA or by precipitating it, we can result the harmful nature of heavy metals in our blood and from water to complete neutralization for our good and for nature as a result of this I decided on this experiment as this experiment will clear a path for me that involves an answer for this environmental issue.

1.1) Background Information:

A heavy metal is a metallic element which has a relatively high density and or atomic weight. These metals are called heavy metals because per same volume as other metals these elements have more weight. Heavy metals are a great part of our lives as they can be found everywhere from the use of lipsticks to ship building and its even dissolved in water. Lead is a heavy metal that is known to be very hazardous to nature, plants and human health especially when dissolved in water. The problem with lead dissolved in water is that lead can be dissolved homogenously, almost as good as salts, which means that lead cannot be separated from water using physical methods. Thus, requiring chemical and more difficult methods to get rid of excess lead dissolved in water.

Heavy metals in our daily life can be found almost everywhere from basic lipsticks to even complicated ships as an example, myth which heavy metals especially lead is used in lipsticks is true; "*The Food and Drug Administration and the Campaign for Safe Cosmetics began researching lead in lipstick around 2007: They found that 61 percent of 33 popular lipstick brands tested positive for lead. An expanded 2010 study by the FDA found lead in over 400 different lipsticks. Researchers at the University of California discovered that lead isn't the only thing to be wary of: They found toxic metals like chromium, aluminium, and manganese*

can also turn up in beauty products."[1]. Heavy metals are especially used for production of ship hulls as ships need a heavy ballast in their hull for reason of ships are supposed to be stable platforms on water and lead is a great option, used for this purpose almost always and in big numbers. Hence, ships are metal fury's which have high usage of lead, that is hazardous to nature an example, average tonnage of a cruise ship in 2016 is approximately 225 tons [2]. Ships are always in water even when they are decommissioned thus, increasing the hazards they cause to nature and human health. If they are to decompose in water releasing and dissolving lead in water, a very high proportional amount of lead in hull as ballast weight which is always under water line of a ship which means full interaction of lead with water.

As we use lead in our daily life almost consistently, we are affected from its hazards. Heavy metals are known for their toxicity and hazards to nature and human health. Lead in human body is distributed to brain, livers kidney and bones and it is especially stored in bones. Lead is extremely hazardous both for the fetus and the mother because, Lead in bone is released to blood during pregnancy and becomes a source of toxicity to the fetus and the mother. Lead can travel extremely long distances before setting down to soil as particles even though it is a heavy and a dense metal and it can be dissolved into the water for the plant or vegetables to be hydrated. Hydration of lead with water can be harmful to plants and for any living being that feed of that vegetable as lead will be stored inside the plant and the product just like in human storage of heavy metals.

With all problems that lead causes to humans, there should be a way to determine lead dissolved in water. However, lead dissolves in water like a salt so it is impossible to separate lead and water physically but with the help of chemistry there are ways of determining lead that dissolved in water. One of the ways of determining is "Gravimetric Method" this method is based on precipitation of lead using Na_2S creating PbS lead(II) sulphide, an insoluble salt precipitate. Another way of determining lead in water is "Complexometric Back Titration

Method" this method is done with and based on EDTA which is a chelating agent, that will form a complex with Lead creating $Pb(EDTA)_2$. However, resulting solution will be homogenous unlike the first method (Gravimetric Method) thus, will need a determination of excess EDTA that is left after the reaction, determination of excess EDTA is used by titrating the solution with $ZnSO_4$ (Zinc Sulphate) until solution changes colour.

What is a Chelating agent and when it is used? A Chelating agent is a molecule that can form two or more separate coordinated bonds between a multi-bonded ligand and a single central atom. As a great example, EDTA is a Chelating agent, and it is used for Chelation therapy, where this agent is used to remove heavy metals from the blood stream. EDTA is a hexadentate with empirical formula of $C_{10}H_{16}N_2O_8$ and structural formula of:

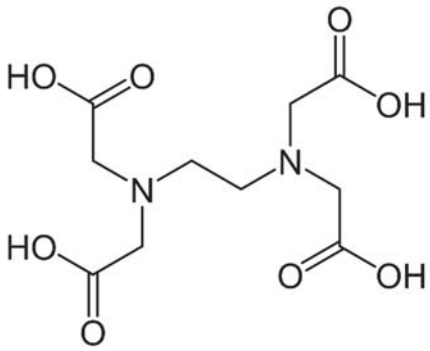

Figure 1: Ethylenediaminetetraacetic acid

1.2) Literature Review:

There are a few other ways of determining lead in water, as other articles cover them. "Spectrophotometric Determination of Lead" in this article lead poisoning was the main focus and it uses ICP-MS method (Inductively Coupled Plasma Mass Spectrometry) to determine lead dissolved in water. Second article is "Determination of lead in water samples by graphite furnace atomic absorption spectrometry after cloud point extraction". In this article a heavy emphasis is put on environmental damage of lead and it is based on creating a pre-concentration of lead with cloud point extraction. Determination is done by graphite furnace atomic absorption spectrometry. Another article on determining lead in water is by the Novel Method,

the article "NOVEL METHOD FOR MICRO DETERMINATION OF LEAD IN WATER SAMPLES". This article puts its weight on human health affected by lead and it once again uses, graphite furnace atomic absorption spectrometry for its way of determination of lead in water.

2. METHOD:

2.1) Research Question: Which method is more effective in determining the amount of Pb^{2+} ions in mole found in water; precipitating Pb^{2+} ions in water sample as PbS (L1ead(II) Sulfide) by using Na_2S (Sodium Sulfide) or by titrating the excess EDTA with $ZnSO_4$ (Zinc Sulfate) solution when EDTA is added to the water sample containing Pb^{2+} ions?

Hypothesis: Precipitation of Pb^{2+} with Na_2S is more efficient method to determine the amount of Pb^{2+} ions in mole found in water than forming a complex with Pb^{2+} and EDTA. The reason behind this is that precipitation is simpler and in titration it is hard to determine the end point of second method.

2.2) VARIABLES:

Variable Types:	Variables:	Explanations:
Dependent Variable(s):	1. Mass of PbS (lead(II) sulphide).	Determined after mixing water sample containing Pb^{2+} ion with Na_2S solution and filtering the products and drying and weighing.
Independent Variable(s):	1. method used to determine amount of Pb^{2+} ions in sample water.	Gravimetric Method is done by mixing $Pb((NO_3)_2$ and Na_2S to form a precipitate which is PbS and filtering it to allow only PbS and filter paper thus, amount of PbS precipitated.
Controlled Variable(s):	1.Temperatures of solutions.	Trials are made in the same environment thus, same temperature.
	2. Volume of water sample containing Pb^{2+} ions and concentration of Pb^{2+} ions.	In each water sample, there is $2.5x10^{-3}$ mole Pb^{2+} ions.
	3. Volume and concentration of Na_2S in solution.	In each water sample, there is $5.0x10^{-3}$ mole of Na^{1+} ions.

Table 1: Variables of the first Method: Gravimetric Method.

Variable Types:	Variables:	Explanations:
Dependent Variable(s):	1. Volume of $ZnSO_4$ solution.	Determined mixing Pb^{2+} solution with EDTA, pH=10 solution and Eriochromo Black T and titrating it with $ZnSO_4$ until end point.
Independent Variable(s):	1. Method used to determine amount of Pb^{2+} in mole in the solution.	Complexometric back titration method is based on forming a complex between EDTA and Pb^{2+} in water and finding amount of excess EDTA by titrating it with $ZnSO_4$ solution.
Controlled Variable(s):	1. Concentration of $ZnSO_4$ solution	Concentration of $ZnSO_4$ is 0.01M.
	2. Temperature of solutions.	The trials are made in the same environment thus, same temperature.
	3. Volume and concentration of Pb^{2+} ions in water sample.	There is a certain amount of $Pb((NO_3)_2$ in initial mixture.
	4. Indicator amount: Eriochromo black T	8 drops of indicator were used for every trial.
	5. Amount of pH=10 solution.	20 drops of pH=10 solution was used for every trial.

Table 2: Variables of the second Method Complexometric Back Titration Method.

2.3) MATERIALS and EQUIPMENT:

Materials:	**Explanation:**
0.1M $Pb(NO_3)_2$ (lead(II) Nitrate solution)	125 ml (25 ml per trial)
0.1M Na_2S (sodium Sulfide solution)	250 ml (50 ml per trial)
Filter paper (Qualitative filter paper: Xinxing)	5 (1 per trial)
Owen (ST – 055, 55L)	Set at 60℃.
Ring Stand	(±0.001 g)
Electronic Balance	-
Beaker	-
Graduated cylinder	(±0.1 ml)
Funnel	-
Wash Bottle	-

Table 3: Materials of first method: Gravimetric Method.

Figure 2: A filter paper used in the first method: Gravimetric method. (Xinxing)

Materials:	**Explanation:**
0.01M $Pb(NO_3)_2$ (Lead(II) Nitrate solution)	125 ml (25 ml per trial)
0.01M EDTA (Ethylene diamine tetra acetic acid solution)	375 ml (75 ml per trial)
pH=10 Buffer Solution	10 drops per trial
Eriochromo Black T	8 drops per trial
0.01M $ZnSO_4$ (Zinc Sulfate solution)	250 ml (50 ml per trial)
Burette	50 ml (±0.01)
Conical flask	250 ml
Ring stand	-
Graduated Cylinder	(±0.1 ml)

Table 4: Materials of the second method: Complexometric Back Titration Method.

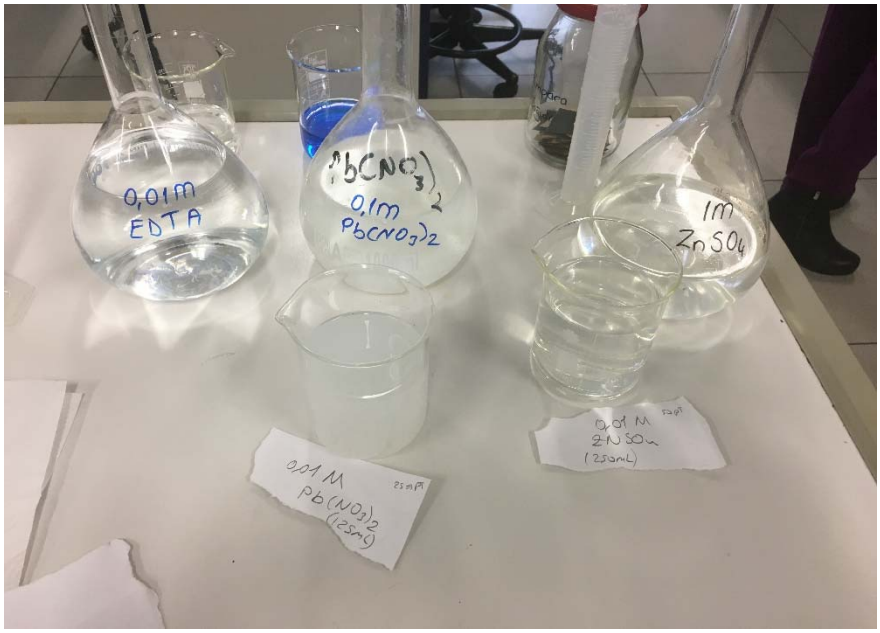

Figure 3: 0.01M of EDTA, 0.01M $Pb(NO_3)_2$ and 0.01M of $ZnSO_4$ with their original concentrations.

2.4) REACTIONS and EXPLANATIONS of METHODS:

Reaction of First Method: Gravimetric Method.

$Pb(NO_3)_{2(aq)} + Na_2S_{(aq)} \rightarrow PbS_{(s)} + 2NaNO_{3(aq)}$

This is a precipitation reaction.

Resultant products will be Lead(II) Sulphide (a black precipitate) and Sodium Nitrate.

Reaction basically involves displacement of Pb^{2+} and Na^{+} ions to form a precipitate (PbS).

Explanation of First Method: Gravimetric Method:

This method is based on precipitation of Pb^{2+} ions in water sample as PbS. Na_2S solution will react with $Pb(NO_3)_2$ solution forming a black precipitate (PbS) to determine the amount of Pb^{2+} in solution. PbS is a black opaque solid, it is obtained by filtering the resultant solution. By heating the filter paper in the oven, we get rid of unwanted water. By weighing filter paper before filtrating and after filtration, with a simple calculation we can determine the mass of PbS precipitate.

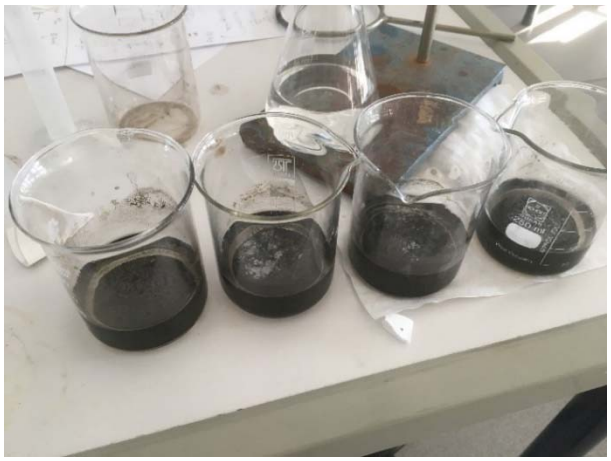

Figure 4: precipitated mixture of Na_2S and $Pb(NO_3)_2$ black solid is PbS.

Figure 5: filtration of resulting mixture.

Reaction of Second Method: Complexometric Back Titration.

$Pb(NO_3)_{2(aq)} + 2EDTA_{(aq)} \rightarrow Pb(EDTA)_{2(aq)} + 2NO_3^{-1}{}_{(aq)}$

This is a complex formation reaction.

$ZnSO_{4(aq)} + EDTA_{(aq)} \rightarrow Zn(EDTA)_{(aq)} + SO_4^{2-}{}_{(aq)}$

EDTA is Chelating agent and forms a complex with Pb^{2+} ions. EDTA is used as excess in the mixture then excess EDTA is titrated with $ZnSO_4$ solution until the end point; colour of solution is turned from Navy-blue to Claret-red.

Explanation of Second Method: Complexometric Back Titration.

This method is based on forming a complex of pb^{2+} ions and EDTA. In this solution, we mix excess amount of EDTA, we will define how much EDTA has been reacted with Pb^{2+} ions by titrating the excess EDTA with $ZnSO_4$ solution. Titrating the solution with $ZnSO_4$ will turn the indicator Eriochromo black T (which is Navy-blue) to Claret-red. $ZnSO_4$ gives a reaction of 1:1 ratio with EDTA thus, ml of $ZnSO_4$ used will give us excess EDTA. Subtracting excess EDTA from starting value (which is 75ml) will give us how much EDTA was used to react with Pb^{2+} ions in $Pb((NO_3)_2$ solution.

Figure 6: Resulting mixture of Complexometric Back Titration method, coloured: Claret-red

2.5) PROCEDURE:

2.5.1) Procedure of First Method: Gravimetric Method.

1) Take weighing cup and put the cup on electronic balance then re-zero then put 33.12 g (which is 0.1 mole of $Pb(NO_3)_2$) onto the cup. Carefully put $Pb(NO_3)_2$ onto the cup with a spatula.

2) Put the weighed the $Pb(NO_3)_2$ in the first step into a volumetric flask, add a small amount of water gently shake the flask and repeat until reached to 1L mark which is at the neck of the flask mostly marked with white.

3) Get a weighing cup again and put it on an electronic balance then press re-zero. Put 7,804 g of Na_2S on it.

4) Put Na_2S we weighed in the first step into a volumetric flask and add water into the flask one by one when we are sure it dissolved enough while gently shaking the flask this will allow us to have a dissolved Na_2S. continue until reached neck mark on the flask.

5) Pick 5 filter papers and weigh them then note them.

6) Fold the filter paper to half and make a cone shaped paper then put it on funnels, wet the paper to get rid of unwanted air and make the paper stick to funnels.

7) Pour the solution slowly through funnel and filter paper, use water to remove PbS precipitate that stick to the beaker and once again pour it until no precipitate left in the beaker.

8) Then, fold the filter papers openings to not let PbS out.

9) Heat the oven to 60° C and leave the filter paper for 15 minutes so water evaporates leaving PbS precipitate and filter paper only.

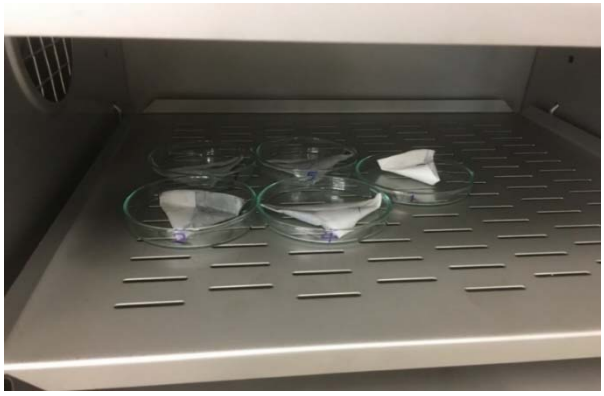

Figure 7: Filter paper in the oven to evaporate any leftover water.

2.5.2) Procedure of Second Method: Complexometric Back Titration.

1) Put 25ml of 0.1M $Pb(NO_3)_2$ solution and add 225ml of pure water this will create 250ml of 0.01M $pb(NO_3)_2$ solution.

2) Put 50ml of 0.1M EDTA and add pure water until solution reaches 375ml which is 337.5ml of pure water. This will make 0.01M EDTA solution.

3) In a beaker mix 50ml of 0.01M $Pb(NO_3)_2$ and 125ml of 0.01M EDTA using 100 ml graduated cylinder for 0.01M $Pb(NO_3)_2$ and 200 ml graduated cylinder for 0.01M EDTA. Read the graduated cylinder value that is bottom of the meniscus. (EDTA should be excess thus, not 100ml but 125ml and $Pb(NO_3)_2$ and EDTA have a 1:2 ratio).

4) Add about 10 drops of 10 PH buffer solution to the beaker.

5) Add 8 drops of indicator black T to the beaker. (this will make the solution Navy-blue)

6) Put a little amount of 0.01M $ZnSO_4$ in to a burette and wash it with it. Then fill $ZnSO_4$ to 50 ml of the burette. Careful to read the bottom of the meniscus.

7) Take an empty cup and pour a very small amount of $ZnSO_4$ into it. This is made to release air from the cone of the burette.

8) Put white paper under beaker between stand and beaker, so that we can see the colour change.

9) Pour $ZnSO_4$ into the beaker while gently shaking the solution so that it will mix.

10) Look for the colour of the mixture to change to Claret-red. Once it changes to claret red stop titrating and note the amount of $ZnSo_4$ used. (Mind the adhesion curve look for the bottom of the meniscus.)

3. Safety instructions:

- Wear gloves and safety-goggles while conducting the experiment since heavy metals are extremely hazardous in aqueous form.
- Do not allow the substances anywhere near your nose, mouth, eyes as heavy metals are especially hazardous when in touch with the skin in aqueous form and in gaseous form.
- Do not inhale or smell the mixtures involving heavy metals as heavy metals will mix with your blood causing a toxic raise of heavy metals in your blood stream.

4. Waste and Disposal:

Be sure not to spill or throw away the waste in the all-purpose bin or drainage, as these wastes will be toxic and harmful to nature. Be sure not to allow it to cause any harm to nature, collect the waste in special bins, “Chemical Waste”. Compound of $Pb(EDTA)_2$ is an aqueous solution thus, dissolvement and mixing with other liquids will be a problem, be sure not to throw it away to the drainage.

Figure 8

5. QUALITATIVE DATA:

5.1) Gravimetric Method:

1) Precipitate of PbS is coloured Black. (**Figure 4** and **Figure 5**) Precipitate that is the result of the first method which is PbS is coloured black as it can be seen in figures 4, 5.

2) $Pb(NO_3)_2$ is a solid coloured white and when it is ionized in water it makes the colour of the solution change from colourless to foggy white. (**Figure 3**)

3) Na_2S which is an element that smells like rotten egg, that is coloured a tilted beige and when it gets dissolved in water mixture is colourless.

4) Filter paper (Xixing) is round and white-beige coloured. (**Figure 2**)

5) When the precipitate has been formed as result of the reaction, smell of Na_2S is neutralized.

5.2) Complexometric Method:

1) Eriochromo black T indicator, will make the solution Navy-Blue coloured. However, after titration with $ZnSO_4$, EDTA and $ZnSO_4$ reacts that makes the solution become Claret-Red coloured.

2) Solution of 0.1M and 0.01M $Pb(NO_3)_2$ is coloured a tilted white. (**Figure 3**)

3) EDTA is a colourless compound. (**Figure 3**)

4) $ZnSO_4$ is a colourless compound as well. (**Figure 3**)

Figure 9: Mixture before titration with $ZnSO_4$ coloured Navy-Blue.

Figure 10: Mixture after titration with $ZnSO_4$ coloured Claret-Red.

Data Collection and Processing:

First Method: Gravimetric method

Trial number:	Weight of the Filter paper (±0.001) (g)	Initial Weight of filter paper + $PbS_{(s)}$ (±0.001) (g)	Calculated Weight of $PbS_{(s)}$ (±0.002) (g)
1	0.786	1.513	0.727
2	0.831	1.344	0.513
3	0.758	1.311	0.553
4	0.806	1.342	0.536
5	0.781	1.327	0.546

Table 5: Data table of Gravimetric Method

Theoretical value of Pb^{2+} ions: M=n/V, $0.1=n/0.025$, $n=2.5x10^{-3}$

If we assume that $Pb(NO_3)_2$ ionizes in water at 100%, mole value of Pb^{2+} ions are equal to the mole value of $Pb(NO_3)_2$.

Weight of PbS ➔ $2.5x10^{-3}$ x 239.08= **0.59779 g**

Mean of experimental values of Pb^{2+} Ions: (0.727+0.513+0.553+0.536+0.546)/5= **0.575 g**

Uncertainty of error percentage: $(0.727-0.513)/2\sqrt{5}$= **±0.239**

1st trial:

Mass of PbS: (weight of filter paper + PbS – total weight of filter paper)

1.513 ±0.001 – 0.786 ±0.001= 0.727 ±0.002

Number of moles of Pb^{2+} in sample water:

Calculation of percentage uncertainty: (0.002/0.727)x100= ±0.275%

0.727/239.08= 0.00241 (±0.275%)

Calculated results of first method: Gravimetric method:

Percentage error: (|0.00241-0.0025|/0.0025)x100= **3.60% (±0.239)**

Second Method: Complexometric Back Titration

Trial number:	Volume of 0.01M $ZnSO_4$ used in titration: (ml) (±0.01)	Volume of EDTA reacted with Pb^{2+} ions in sample water: (ml) (±0.02)
1	21.5 (This value is too different from other values thus, won't be used)	53.5 (Value is too different so it won't be used)
2	11.7	31.65
3	8.3	33.35
4	11.0	32.00
5	9.5	32.75

Table 6: Data table of Complexometric Method

Theoretical value of Pb^{2+} ions in sample water: 0.01=n/0.025 ➔ n= 0.0025 mole

2nd trial:

Initial mole value of 2EDTA: 0.01 0 n/0.075 ➔ n= $7.5x10^{-4}$

Uncertainty of initial mole of 2EDTA: (0.1/75)x100= ±0.13%

Mean of experimental values of Pb^{2+} ions:

Initial volume of EDTA – Amount of $ZnSO_4$ = Amount of EDTA used

Net ion reaction of Pb^{2+}: $Pb(NO_3)_{2\,(aq)}$ ➔ $Pb^{2+}{}_{(aq)}$ + $2NO_3(-)_{(aq)}$

ml of EDTA reacted with Pb^{2+}: 75.0 – 11.7= 63.3ml (±0.02)

Volume of Pb^{2+} reacted in sample water:

63.3/2= 31.65ml (±0.2%)

Uncertainty: 0.13+0.085= ±0.2%

Moles of Pb^{2+} neutralized in sample water:

$31.65x10^{-3}x0.01= 3.165x10^{-4}$ mole (±0.2%)

Uncertainty for error percentage: $((3.365-3.165)x10^{-4})/2\sqrt{4}$**= ±0.05x10^{-4}**

Calculated results of second method: Complexometric Back Titration

Percentage error: $(|3.25125x10^{-4}-2.5x10^{-4}|/2.5x10^{-4})x100$= **30.05% (±0.05x10^{-4})**

Processed Data Tables:

Trial Number:	Average number of moles of Pb^{2+} in sample water: (moles) (3sf) (±0.28%)
1	0.00219
2	0.00155
3	0.00167
4	0.00162
5	0.00165
Mean of pb^{2+} ions in sample water:	**0.00174**

Table 7: Results of first method: Gravimetric Method

Trial number:	Average number of moles of pb^{2+} in sample water: (moles) (3sf) (±28.9%)
2	$3.165x10^{-4}$
3	$3.365x10^{-4}$
4	$3.200x10^{-4}$
5	$3.275x10^{-4}$
Mean of moles of Pb^{2+} reacted in sample water:	**$3.25125x10^{-4}$**

Table 8: Results of second method: Complexometric Back Titration Method

6. CONCLUSION:

In this experiment, most efficient method for neutralizing Lead dissolved in water was aimed to be found. Dissolved heavy metals in water are extremely dangerous in this case Lead as heavy metal in water is precipitated or neutralized for making it harmless to environment and living beings. The result was found by making two experiments using two different methods with 5 trials each to lower error and comparing the results with theoretic and experimented results with percentage error. The extracted data results show us that, first method: Gravimetric method is more accurate than the second method: Complexometric Back titration as it has approximately 26.45% less error. This might have been caused by the end point random errors. The experiments could have been made in a water bath as temperature might have changed during the experiment and to reduce the differences in Gravimetric Methods errors, pure water used to solute the initial mixture could have gone more purification process to make it so that less materials in water existed.

6.1) EVALUATION:

Gravimetric method of neutralizing lead in sample water is more efficient and effective than Complexometric Back titration method. EDTA forms a complex with lead but precipitating lead with Na_2S is more efficient in neutralizing lead in sample water. precipitation is a simpler method thus, error in its process is less.

6.2) LIMITATIONS:

Definite solutions: Preparing our own solutions helped us define the experimental values of mole of Lead in sample water. However, difficulties in defining endpoint of titration and colour change of titration can and will lead to errors. Another limitation is that temperature could have changed during the trials as even tough trials were made in the same place, a water bath could have suit the experiments better.

APPENDICES:

Molar mass of elements and molecules:

Pb: 207.02

N: 14,01

S: 32.06

Na: 22.98

EDTA: 292.24

Zn: 65.38

O: 16.00

$Pb(NO_3)_2$ = 207.02 + 2x(14,01+3x(16.00)) = 331.22

Calculations for Gravimetric method:

Trials:

2^{nd}: 0.513/331.22 = 0.00155

3^{rd}: 0.553/331.22 = 0.00167

4^{th}: 0.536/331.22 = 0.00162

5^{th}: 0.546/331.22 = 0.00165

Mean: (0.00129+0.00155+0.00167+0.00162+0.00165+0.00174)/5 = 0.00174

Calculations for Complexometric Back Titration method:

Trials:

2^{nd}: 75.0-11.7 = 63.3/2 = 31.65, $31.65x10^{-3}x0.01= 3.165x10^{-4}$

3^{rd}: 75.0-8.3 = 66.7/2 = 33.35, $33.65x10^{-3}x0.01 = 3.365x10^{-4}$

4^{th}: 75.0-11.0 = 64/2 = 32.00, $32.00x10^{-3}x0.01 = 3.200x10^{-4}$

5^{th}: 75.0-9.5 = 65.5/2 = 32.75, $32.75x10^{-3}x0.01 = 3.275x10^{-4}$

Mean = $(3.165+3.365+3.200+3.275)x10^{-4}/4 = 3.25125x10^{-4}$

REFERENCES:

Quotes:

[1]: https://www.rd.com/health/beauty/lead-in-lipstick/

[2]:https://www.statista.com/statistics/264515/ranking-of-the-cruise-ships-worldwide-by-gross-tonnage/

Literature Reviews:

1) ICP-MS method: http://www.pharmtech.com/spectrophotometric-determination-lead

2) Determination of lead in water samples by graphite furnace atomic absorption spectrometry after cloud point extraction: https://www.researchgate.net/profile/Houda_Kawas/post/the_function_of_triton_X_in_AAS/attachment/59d64e2479197b80779a78a9/AS:491448446525440@1494181848046/download/0c960522bcc20e88f8000000.pdf

3) NOVEL METHOD FOR MICRO DETERMINATION OF LEAD IN WATER SAMPLES**:** http://www.tsijournals.com/articles/novel-method-for-micro-determination-of-lead-in-water-samples.pdf

Figures:

1)Figure 1: https://en.wikipedia.org/wiki/Ethylenediaminetetraacetic_acid

2) Figure 8: https://www.firstaidandsafetyonline.com/caution-chemical-waste-storage-area-sign-1/

3) Molar Mass of EDTA: https://m.wikipedia.org/wiki/Ethylenediminetetraacetic_acid

Molar mass of atoms: Chemistry IB Data Booklet