

**THE EFFECT OF TEMPERATURE AND
CONCENTRATION ON THE ADSORPTION OF Pb^{2+} AND
 Ba^{2+} CATIONS IN A DRY CELL USING TITANIUM (IV)
OXIDE**

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DECLARATION

I hereby declare that, this project is my original work and has never to my knowledge been submitted elsewhere before.

Abiodun Olanrewaju

date

CERTIFICATION

This is to certify that I have supervised, read and approved this project report, and have found it satisfactory both in scope and quality for the partial fulfillment of the requirement for the award of Bachelor of Engineering in Chemical Engineering

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Date

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Date

External examiner

Date

DEDICATION

You see life is a course in which we are privileged to be a part of, therefore I deem it most necessary to dedicate any singular achievement including this one, to whom has given me the privilege to be here. Almighty Father, thank you.

Dad and Mom, I love you and appreciate you so much we will stick together for eternity, my sister, Ronke, you know you are my angel, to my brother, Tayo, thanks for being there and setting me on the path with your advices and love, my brother Sola, I'll always respect you for your talents and stern principles.

ACKNOWLEDGMENT

I will like to show my appreciation, respect and gratitude to my supervisor, Dr Aloko, for being very patient as a father would with me, May God repay your kindness with fulfillment in life.

And now finally to all my Guys, y'all know I got your back, Lets take a look back in time and send shout outs; Toyosi, miss you holmes, D shoota, D Grande, Trik poppa, Valcohol, Obaitan, Shevchenko the shaver, Bodman, Ochman caly, D Jhiro, Jido Oosha, Crazy Malo, Don Babe, El Zizo, Makalele Mokujin, Nose, Oligi and the rest of the crew . And to the queen of my heart (nah just kidding). To my kpoms, love y'all. ;.
Slushing begins. Fade

ABSTRACT

Analyses were done to determine the effect of temperature and concentration on the adsorption of Ba^{2+} and Pb^{2+} ions using TiO_2 in a dry cell. From the analyses done, using the method of potentiometric titration, tables and graphs were drawn which gave results that showed, with an increase in temperature, and decrease in concentration, the blending of TiO_2 with Pb^{2+} and Ba^{2+} increases the voltage output and lifespan of a dry cell. This works particularly at with Ba^{2+} at pH between 9.4 to 9.6, at temperature of $35^{\circ}C$ and a concentration of 0.01M; at which the highest charge is produced from results obtained

CHAPTER ONE

1.0 INTRODUCTION

A dry cell is an early name for the non-rechargeable battery that is still used occasionally. The early non-rechargeable batteries were laboratory devices (e.g. The Daniel cell), which is a simple device which converts chemical energy directly to electrical energy. It consists of two galvanic, or electrochemical, cells that produce direct current electricity. To produce a practical device the electrolyte solution (i.e. a chemical compound (salt, acid or base) that dissociates into electrically charged ions when dissolved in a solvent.) was "immobilized" by some gelling agents, and the whole cell was sealed to permit its use in any position. Hence, the name "dry cell". The objective of this work is to determine the effect of temperature and concentration on the adsorption of cations on the dry cell.

The dry cell is known as a primary electrochemical cell, which is a device that carries out chemical reactions occurring in the cell. Typically, it consists of two metal electrodes immersed in an aqueous solution (electrolyte) with electrode reactions occurring at the electrode solution surfaces. These reactions occur in cells called the galvanic cells (dry cells) and the electrolytic cell (secondary-rechargeable electrochemical cell).

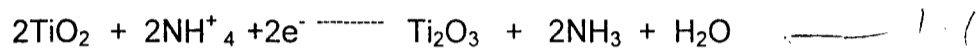
The dry cell always operates as a galvanic cell, consequently, the anode is the negative electrode, while the cathode is the positive electrode, chemical reactions occur spontaneously when they are connected through an external circuit, producing an electric current.

Emphasis will be laid on the Leclanche dry cell, but titanium (iv) oxide will be used as the depolarizer in this experiment as against manganese (iv) oxide in the original Leclanche cell which uses a zinc container anode (negative electrode) and a carbon rod cathode (positive electrode) the electrolyte consists of powdered

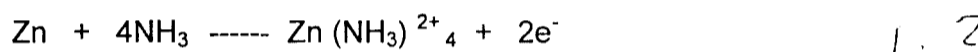
carbon -zinc chloride, ammonium chloride, water, manganese (iv) oxide (MnO₂) and an inert tiller in the form of paste, the salt bridge is a porous liner placed between the zinc container and the paste to prevent contact. To increase the storage life, the porous liner (non-conductor) contains zinc and mercuric chlorides mixed together in certain cases.

The reaction that occur when electrons are conducted from the anode to the cathode (flow of current) in the cell are:

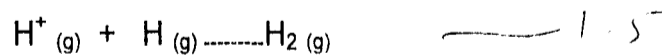
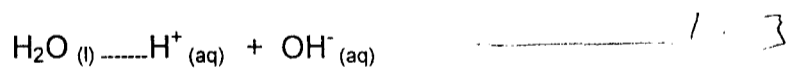
At the cathode;



At the anode;

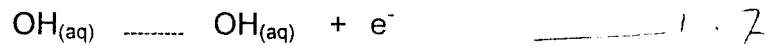
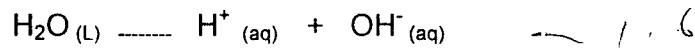


By the ionization of water, hydrogen ions (H⁺) are formed which move to the cathode and become hydrogen atoms, the atoms (hydrogen) then combine to form hydrogen gas formed at the cathode, this is done because the accumulation of hydrogen gas will kill the cell on time, so manganese (iv) oxide is used to reduce the accumulation of hydrogen gas and in turn increase the life span of the cell. the reaction for the formation of the hydrogen gas is as shown below:

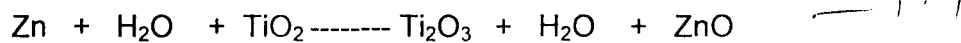


At the anode, also from the ionization of water molecules, the hydroxyl group (OH) is formed from the loss of an electron. These hydroxyl groups formed, combine to form water molecules (H₂O) and one oxygen atom (O), they serve to maintain the

electrolytic-moisture (paste) at the anode. The reaction for the formation of the water molecule (H₂O) and oxygen (O) is shown below:



The overall reaction that occurs in the cell is the sum of reactions occurring at both electrodes (cathode and anode) and is as shown below



The life span of the cell depends a large part on the extent of formation and accumulation of hydrogen gas, voltage discharge is reduced, and the storage life and life span, after which the cell dies at a certain level of hydrogen gas accumulation and the depolarizer (the material added to the battery electrode for reducing the polarization upon application of a current) reduces the amount of hydrogen gas formed which in turn increases the cell's life span. The depolarizer used in this case is Titanium (iv) oxide; test and experiments will be run to determine the effectiveness of TiO₂ as a depolarizer.

In running these tests, the adsorption method by potentiometric titration is to be used, whereby sodium hydroxide solution will be titrated against a salt solution containing cations into which a specific weight of titanium (iv) oxide is added. The PH level of the salt solution containing sodium hydroxide and that without TiO_2 at a different concentration and temperature by adding the base (NaOH) are noted, which will be related to adsorption. this will affect the determination of the most suitable concentration at a certain temperature for the adsorption process, from the analysis that will be done, the result ascertain the most effective concentration and temperature that sodium hydroxide will best act as a depolarizer, and will give a longer life span for the cell.

Titration will also be done to acquire the surface area of TiO_2 , this is attained by adsorption from the solution used for the titration.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

The first evidence of battery come from archaeological digs in Baghdad, Iraq. This first "battery" was dated to around 250 B.C and was used in sample operation to electroplate object with a thin layer of metals, much like the process used now to plate inexpensive gold and silver jewelry. One of the first uses for batteries.

The later battery development date in the late 18th century. The cause was championed by the work carried out by Luigi Galvani from 1780 to 1786. Through his experiments, galvanic observed that when connected pieces of iron and brass were applied to frog's legs they caused them to twitch. However, Galvani thought that the effect originated in the leg tissue. Nevertheless, galvanic had laid the cornerstone for further development in "voltaic" electricity.

From 1796 to 1799, Alessandro Volta with zinc and silver plates to produce electric current at the Pavia university. Volta stacked the two to form a "pile", the first "dry" battery. By 1800, Volta had created the "crown of cups", a modified arrangement of zinc and silver, dipped in as salt solution.

In the years that ensued, other means of producing electricity were invented, all of which involved the use of liquid electrodes. One of them is the English chemist, John Fredrick Daniel (1836), whose invention was named after him, which is known as the "Daniel cell". Those developed by Bensen (1842) and Grove (1839) were amongst the most successful systems and were used for many years.

By 1866, Georges Leclanche, a French engineer, patented a new system, which was immediately successful. In the space of two years 20,000 of his cells were being used in the telegraph system. Leclanche's original cell was assembled in a porous pot with a zinc rod as anode, manganese dioxide mixed with carbon as cathode and ammonium chloride as electrolyte, with leclanche's invention, which

was quite heavy and prone to breakage, was steadily improved over the years. The idea of encapsulating both the negative electrode and a porous pot into a zinc cup was first patented by J.A thiebant in 1881. But it was Earl Gassner of Mainz who is credited as producing the first commercial successful "dry" variation followed. By 1889, there were at least six well- known dry batteries in circulation. Later battery manufacturing produced smaller, lighter batteries, and the application of the tungsten filament in 1909 created the impetus to develop batteries for use in torches.

The production of batteries was greatly increased during the First World War as a means of powering torches, field radios. Other milestones in battery production include the wide spread radio broadcasting, which brought battery operated, wireless into the heart of many homes. But, it was during the inter-war years that battery performance was greatly enhanced. This was achieved through better selection of materials and methods of manufacture.

Batteries have now become an essential part of everyday life. They are the power source for millions of consumer, business, medical, military and industrial appliances world wide. This demand is growing.

2.2 CLASSIFICATION OF BATTERIES:

Batteries are classified into two groups, which are:

- 1) The "primary" battery, in which the chemical reaction system providing the electrical current is not easily "chemically" reversible. That is why they are also called "non-rechargeable" battery.
- 2) The "secondary" battery, which the chemical reaction system providing the electrical current is easily "chemical" reversible. After discharging, it can be recharged by applying an electrical current to its terminals. Some battery can be recharged hundreds to thousand times e.g. the lead acid battery. Also called rechargeable battery.

2.2.1 PRIMARY BATTERY :

This is so called because it provides current until all the chemicals placed in it during manufacturing are used up. It is discharged after a single discharge. It is classified into four types; the dry cells, wet cells, reserve cells and fuel cells.

Dry cell is an early name for the non-rechargeable battery that is still used occasionally. To produce a practical device, the electrolyte solution was "immobilized" by some gelling agent, and the whole cell was sealed to permit its use in any position.

Hence the name "dry cell". The Daniel cell is an example of a dry cell; the leclanche cell is another example that is widely used.

2.2.2 LECLANCHE'S DRY CELL:

Named after, Georges Leclanche. Leclanche's original cell was assembled in a porous pot. The positive electrode consisted of crushed manganese dioxide with a little carbon mixed in it. The negative pole was a zinc rod. The cathode was packed into the pot, and a carbon rod was inserted to act as a current collector. The anode or zinc rod and the pot were then immersed in an ammonium chloride solution. The liquid acted as the electrolyte, readily seeping through the porous cap and making contact with the cathode material. Leclanche's "wet cell" (as was popularly referred to) became the forerunner to the world's first widely used battery, the zinc carbon cell. The liquid electrolyte was later "Immobilized" and this system became the first dry cell.

The leclanche's dry cell are now produced in various forms and packed as unit cell, in different sizes. The cell is used as a means for powering wrist watches, torches, and also packed in large units to power large systems. Typical examples of a dry cell's, that are commonly used are, Duracell and Energizer.

2.3.0. ELECTROCHEMISTRY OF BATTERIES :

The electrochemistry cell is a device that converts chemical energy into chemical energy (galvanic cell) or converts electrical energy into chemical energy (electrolytic cell) when a chemical reaction is occurring in the cell. Typically, it consists of two metal electrodes immersed into an aqueous solution (electrolyte) with electrode reactions occurring at the electrode-solution surfaces.

It consists of two electronically conducting phases (e.g. solid or liquid metals, semiconductors, e.t.c.) connected by an ionically conducting phase (e.g. aqueous or non-aqueous solution, molten salt, ionically conducting solid). As an electrical current passes, it must change from electronic to ionic current and then back to electronic current. These changes of conduction mode are always accompanied by oxidation/reduction reactions. An essential feature of the electrochemical cell is that the simultaneously occurring oxidation-reduction reactions are spatially separated. E.g. in a spontaneous "chemical reaction" during the oxidation of hydrogen by oxygen to water, electrons are passed directly from the hydrogen to the oxygen. In contrast, in the spontaneous electrochemical reaction in a galvanic cell, the hydrogen is oxidized at the anode by transferring electrons to the anode and the oxygen is reduced at the cathode by accepting electrons, from the cathode. The ions produced in the electrode reactions, in this case positive hydrogen ions and the negative hydroxyl (OH) ions, will recombine in the solution to form the final products of the reaction; water. During this process, the electrons are conducted from the anode to the cathode through an outside electrical circuit where the electrical current can dry a motor, light bulb, e.t.c. The reaction can also be reversed; water can be decomposed into hydrogen and oxygen by the application of electrical power in an electrolytic cell.

2.4.0. VOLTAGE

This is the electrical potential difference between the two electrodes of an electrochemical cell. In case of as three electrode cell, the potential difference between the working electrode and the counter electrode.

“Cell voltage” usually refers to non-equilibrium conditions, that is, when current is flowing through the cell (although this convention is not always followed). The term “voltage” s usually reserved for the case when an electrode s considered. (Of course, the latter case is still an “electrochemical cell” consisting of the electrode under consideration and a reference electrode). The terms “voltage” and “potential” are sometimes used interchangeably.

In almost any device that uses batteries (dry cell), one cell is not just used at a time. They are normally grouped together seriously to form higher voltages, or in parallel to form higher current. In a serial arrangement, the voltage adds up, in a parallel arrangement, the current. For example, although the voltage range produced by various forms of cells s about 1.25-2.00 volts; to produce a 9 volts Duracell battery, it contains six very small batteries, producing 1.5 volts each in a serial arrangement.

2.5.0. ADSORPTION:

This is an increase of the concentration of a solute in the vicinity of a solid surface, over that in the bulk of the solution, due to the attractive interaction between the solid immersed into the solution and the solute. Adsorption on a sold from as gaseous phase also occurs. In a simpler definition, adsorption is the taking up by the surface of a sold or a liquid (adsorbent) of the atoms, ions or molecules of a gas or other liquids (adsorbate). Sometimes the word sorption is used to indicate the process of the taking up of a gas or liquid by a solid without specifying whether the process is adsorption or absorption.

2.6.0 PRACTICAL METHODS OF ADSORPTION:

There are three methods that can be used to achieve the aim of this research work, which are namely;

- 1) Electro kinetic method
- 2) Radio chemical method
- 3) Potentiometric Titration Method

But the method of concern for this work is the potentiometric titration method.

2.6.1 THE PRINCIPLES OF POTENTIOMETRIC TITRATION:

A potentiometric titration is a titration to a potentiometric end point involves measurement of the voltage of a cell consisting of two half cells, one of which contains the solution being titrated. The cell voltage is measured without the passage of an appreciable current through the cell. Measurement of the cell voltage allows the titration to be followed and the point to be located. When the pH is to be followed, a glass electrode is often used, which a pH meter, which is the method I will use in my experimental practical, to attain values that will be used to draw graphs; which will be used as a result, to also attain values that will be used to calculate charge.

This method involves the measurement of the e.m.f (electromotive force) between two electrodes, an indicator electrode, the potential of which is a function of the concentration of the ion to be determined, and the reference electrode (an electrode that has a well known and stable equilibrium electrode potential), which will be a large part in determining the e.m.f. In this method, of potentiometric titration, measurements are made while the titration is in progress. The equivalence point of the reaction is revealed by a sudden change in potential, in the plot of e.m.f reading against the volume of the titration solution. An electrode will remain a constant, but

not necessarily a known potential, the other electrode will serve as an indicator of the changes in the ion concentration, and will respond rapidly.

In this method, the apparatus employed for a potentiometric titration are essentially a reference electrode, indicator electrode, magnetic stirrer, beakers and burettes. During the experiment, the e.m.f. of the cell containing the initial solution is determined and relatively, increments of the titrant solution into the titrand at certain amounts is done until the equivalence point is approached, the e.m.f is determined after such addition. Sufficient time should be allowed after each addition, for the indicator electrode to reach a reasonably constant potential before the next increment is introduced.

For this research work, the pH of the solution mixture is determined after each increment of 0.5ml of acid solution into titrant, with or without TiO_2 . These additions and subsequent determination of the pH will be carried out beyond the equivalence point. In order to measure the e.m.f., the electrode system is to be connected to a potentiometer or an electric volt meter.

2.7.0 ELECTRIC CHARGE:

Basically, electric charges are defined as the quantity of electricity that flow in electric currents or that are accumulated on the surface of dissimilar non-metallic substances that are rubbed together vigorously. There are two kinds of charge, positive and negative. Like charges repel, unlike charges attract. Positive charges come from having more protons than electrons; negative charges come from having more electrons than protons. Charge is quantized, meaning that charge in integer multiples of the elementary charge i.e. charge is conserved. In other words, charge comes in multiple of the charge on the electron or the proton. These things have the same size charge, but the sign is different. A proton has a positive charge (+e) while the electron has a negative charge (-e). Electrons are not the only things that carry

charge. Other particles (positrons, for example) also carry charge in multiples of the electronic charge. Neutrons are known to carry zero charge.

Putting "charge is quantized" in terms of an equation, we say;

$$q=ne$$

q is the symbol used to represent charge, while n is a negative or positive integer, e is the electronic charge, 1.60×10^{-19} coulombs.

Electric charge is considered in any isolated system, in any chemical and nuclear reaction, the net electric charge is constant. The surface electric charge;

$$E = nFQ, \text{ where;}$$

E; is the surface electric charge (uc mole/cm²)

N; is the number of ionic charges of the substance

F; is the faraday constant (965000C)

Q; is adsorption (mole/cm²)

This was derived from Nerst equation

$$E^1 - E - \frac{RT}{Nf} \ln \frac{Q \text{ product} - V}{a \text{ reactant}} \dots\dots\dots(1)$$

Where;

E¹ = energy

E = standard electrode

V = Volt

Thus, energy as it relates to charged particles considering faraday adsorbate could be expressed as

$$E = nFV \dots\dots\dots(2)$$

Similarly, surface charge, E as a result of the presence of particles on an adsorbate could be expressed as

$$E = nFQ \dots\dots\dots(3)$$

2.8.0 TITANIUM (IV) OXIDE

Titanium dioxide, also known as **titania** is the naturally occurring oxide of titanium, chemical formula TiO_2 .

Pure titanium dioxide does not occur in nature but is derived from ilmenite or leucocene ores. It is also readily mined in one of the purest forms, rutile beach sand.

Titanium dioxide is the most widely used white pigment because of its brightness and very high refractive index ($n=2.4$), in which it is surpassed only by diamond. When deposited as a thin film, its refractive index and color make it an excellent reflective optical coating for dielectric mirrors. TiO_2 is also an effective opacifier in powder form, where it is employed as a pigment to provide whiteness and opacity to products such as paints, coatings, plastics, papers, inks, foods, and most toothpastes. In cosmetic and skin care products, titanium dioxide is used both as a pigment and a thickener, and in almost every sunblock with a physical blocker, titanium dioxide is found both because of its refractive index and its resistance to discoloration under ultraviolet light. This advantage enhances its stability and ability to protect the skin from ultraviolet light.

The Vinland map, the map of America ("Vinland") that was supposedly drawn during mid-15th century based on data from the Viking Age, has been declared a forgery on the basis that the ink on it contains traces of the TiO_2 -form anatase; TiO_2 was not synthetically produced before the 1920s. Recently (1992) a counter-claim has been made that the compound can be formed from ancient ink.

CHAPTER THREE

3.0 EXPERIMENTAL WORK

3.1.0 CHEMICALS AND EQUIPMENTS

3.1.1 CHEMICALS (used for potentiometric titration)

Titanium (IV) oxide, TiO_2

Sodium Hydroxide, NaOH

Lead (II) nitrate, $\text{Pb}(\text{NO}_3)_2$

Barium (II) nitrate, $\text{Ba}(\text{NO}_3)_2$

All the above salts will be prepared to give 1M, 0.1M, 0.01M, 0.001M, and solution of each cation.

Nitrogen gas (highly compressed at 250 Bar in 1m^3 air liquid cylinder).

Nitrogen is to be used to;

- 1) Provide an inert environment in the titrating beaker and thus inhibit side reaction.
- 2) Drive off oxygen and carbon dioxide, which might be present.
- 3) Nitrogen takes the place of oxygen molecules present in the aqueous solution to provide the necessary electrons that make up the quantity of oxygen by titanium (iv) oxide molecule.

3.2.0 EQUIPMENT

3.2.1 Equipment/ Apparatus (for determination of surface area of TiO_2)

even Erlenmyer flasks with rubber stoppers.

Glass funnels

Seven 250ml pyrex beakers

Analytical balance AE160

Graduated 10ml and 50ml burette

Retort stands

Seven conical flasks 250ml pyrex

Pipettes (various sizes)

Spatula

Wash glass

White tile

Watch glass

3.2.2 EQUIPMENT/APPARATUS (used for the potentiometric titrations)

pH meter EIL 7045/46

Magnetic stirrer - Migma stirrer

Magnetic follower

Weighing balance

50ml burette

25ml pipette

10ml pipette

100ml beakers

250ml conical flasks

250ml, 500ml, 1000ml volumetric flasks

Nitrogen gas regulator (gauge)

Tripod stands and clamps

Funnels

Test tube brush.

3.3.0 POTENTOMETRIC TITRATION.

3.3.1 PROCEDURE:

To a clean, dry 100ml beaker, a little of 1M of lead (II) nitrate ($\text{Pb}(\text{NO}_3)_2$) was added to rinse the beaker. The 50ml of the 1M solution of lead (II) nitrate was measured with a 50ml pipette and transferred into the beaker, and a magnetic follower placed inside to provide continuous stirring. The beaker was placed on a magnetic stirrer, which was connected to a power source. A reference electrode and an indicator electrode (built into one holder) connected to a pH meter were hanged into the solution in the beaker. Then a nitrogen gas jet regulated by a gauge from the nitrogen gas cylinder was additionally inserted into the solution in the beaker such that the gas outlet is immersed into the solution. In addition, a burette filled with 0.1M sodium hydroxide solution was also placed such

When all the instruments have been neatly arranged, the magnetic stirrer was switched on and the nitrogen gas regulator opened to provide a continuous gas jetting into the solution (bubbling).

After a while, when the pH meter was stabilized, and the initial pH reading without the 0.1M solution of sodium hydroxide was noted. Subsequently, 0.50ml of the titrant (base) was added from burette and the pH reading noted for every 2 minutes after each addition in which the indicator electrode had reached a constant value. The 0.50ml increment and the corresponding p reading were noted for a total of 10.00ml additions when no significant change was observed in the reading. The magnetic stirrer and the pH meter were switched off and the solution mixture disposed off, after the titration was over.

Also another 50ml of the 1M lead (II) nitrate solution was poured into the beaker with a pipette (after it has been washed and rinsed with the solution) and 2g of titanium (IV) oxide was also poured into the beaker containing the solution. The magnetic follower was then inserted into the beaker and the whole set-up arranged

after stabilizing the pH meter with distilled water. The same procedure was repeated for a total of 10.00ml of 0.50ml addition of the 0.1M sodium hydroxide solutions. The same procedure that involved with and without titanium (IV) oxide, was repeated for 0.1M, 0.01M, 0.001M and of 10.00ml of 0.50ml addition of the 0.1M sodium hydroxide solution. The same procedure involved with and without titanium (IV) oxide was repeated for 0.1M, 0.01M, 0.001M solutions of lead (II) nitrate all were done at three different temperatures, 29°C, and 35°C.

This whole procedure was repeated but this time using barium nitrate, the pH readings at different 0.50ml volume of base added were noted and tabulated.

From the tabulated results, graphs will be drawn for each set of readings (both pH of solutions with and without titanium (IV) oxide and for all concentrations of the different cations.

CHAPTER FOUR

4.0 RESULTS

The specific surface area of titanium (iv) Oxide was calculated to be 59573493 cm^2/g . it will be used in calculations

TABLE 4.1.0 TABLES OF RESULTS FROM POTENTIOMETRIC TITRATION EXPERIMENT

The following table below are the results from the Potentiometric titration that were done

Table 4.1: 1 M Pb(NO₃) at 29^oC
0.1 M Vol

NaOH	Without TiO ₂	With TiO ₂
0	4.05	4.25
0.5	4.34	4.4
1	4.43	4.48
1.5	4.48	4.54
2	4.51	4.57
2.5	4.53	4.59
3	4.54	4.62
3.5	4.56	4.63
4	4.56	4.64
4.5	4.56	4.65
5	4.56	4.65
5.5	4.56	4.65
6	4.56	4.65
6.5	4.56	4.65
7	4.56	4.65
7.5	4.56	4.65
8	4.56	4.65
8.5	4.56	4.65
9	4.56	4.65
9.5	4.56	4.65
10	4.56	4.65

Table 4.2 0.1 M Pb(NO₃) at 29^oC

Volume of NaOH	Without TiO ₂	With TiO ₂
0	4.48	4.75
0.5	5.03	5.06
1	5.09	5.28
1.5	5.13	5.38
2	5.16	5.43
2.5	5.18	5.46
3	5.21	5.49
3.5	5.23	5.51
4	5.25	5.51
4.5	5.26	5.53
5	5.28	5.53
5.5	5.3	5.55
6	5.31	5.57
6.5	5.33	5.58
7	5.34	5.6
7.5	5.34	5.61
8	5.33	5.62
8.5	5.32	5.64
9	5.32	5.65
9.5	5.32	5.65
10	5.32	5.66

Table 4.3 0.01 M Pb(NO₃) at 29^oC
0.1 M Vol

NaOH	Without TiO ₂	With TiO ₂
0	5.45	4.98
0.5	5.94	4.91
1	6	6.02
1.5	6.06	6.1
2	6.11	6.19
2.5	6.16	6.25
3	6.21	6.31
3.5	6.27	6.38
4	6.34	6.45
4.5	6.41	6.52
5	6.48	6.59
5.5	6.61	6.7
6	6.74	6.83
6.5	7.02	7.01
7	7.49	7.4
7.5	7.5	7.75
8	7.54	7.68
8.5	7.56	7.76
9	7.7	7.89

Table 4.4 0.001 M Pb(NO₃) at 29^oC
0.1 M Vol

NaOH	Without TiO ₂	With TiO ₂
0	6.28	5.49
0.5	7.2	6.31
1	9	7.87
1.5	9.59	9.35
2	9.74	9.7
2.5	9.85	9.81
3	9.91	9.86
3.5	9.98	9.91
4	10.02	9.94
4.5	10.07	9.98
5	10.09	10.02
5.5	10.12	10.05
6	10.15	10.08
6.5	10.17	10.1
7	10.18	10.13
7.5	10.2	10.15
8	10.22	10.18
8.5	10.24	10.2
9	10.26	10.22

Table 4.5 1 M Pb*NO₃ at 35°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	4.46	4.54
0.5	4.72	4.86
1	4.79	4.88
1.5	4.85	4.92
2	4.89	4.95
2.5	4.92	4.99
3	4.96	5.03
3.5	4.98	5.06
4	5.01	5.08
4.5	5.04	5.11
5	5.09	5.13
5.5	5.11	5.16
6	5.14	5.18
6.5	5.17	5.22
7	5.19	5.24
7.5	5.22	5.25
8	5.24	5.28
8.5	5.25	5.31
9	5.29	5.33
9.5	5.31	5.36
10	5.33	5.38

Table 4.6 0.1 M Pb*NO₃ at 35°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	5.16	5.35
0.5	5.41	5.56
1	5.46	5.65
1.5	5.51	5.71
2	5.54	5.75
2.5	5.58	5.79
3	5.61	5.82
3.5	5.64	5.84
4	5.66	5.88
4.5	5.69	5.9
5	5.72	5.92
5.5	5.77	5.93
6	5.88	5.94
6.5	5.9	5.95
7	5.91	5.96
7.5	5.93	5.97
8	5.95	5.99
8.5	5.99	6.01
9	6.02	6.02
9.5	6.04	6.04
10	6.06	6.05

Table 4.7 0.01 M Pb*NO₃ at 35°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	6.18	5.48
0.5	6.79	6.26
1	6.92	6.6
1.5	7	6.7
2	7.06	6.78
2.5	7.15	6.82
3	7.23	6.95
3.5	7.29	7.07
4	7.37	7.15
4.5	7.47	7.3
5	7.58	7.53
5.5	7.73	7.94
6	7.97	8.24
6.5	8.37	8.56
7	8.69	8.85
7.5	8.75	9.02
8	8.79	9.22
8.5	8.87	9.43

Table 4.8 0.001 M Pb*NO₃ at 35°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.04	6
0.5	8.04	6.95
1	9.56	8.4
1.5	10.17	9.2
2	10.21	9.31
2.5	10.31	9.37
3	10.39	9.42
3.5	10.47	9.5
4	10.54	9.56
4.5	10.61	9.6
5	10.65	9.64
5.5	10.71	9.66
6	10.75	9.79
6.5	10.79	9.73
7	10.83	9.75
7.5	10.86	9.78
8	10.89	9.81
8.5	10.92	9.83

Table 4.9 1MBaNO₃₂ at 29°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	6.45	6.56
0.5	7.43	7.03
1	8.6	7.62
1.5	9.09	8.39
2	9.27	8.91
2.5	9.39	9.19
3	9.46	9.37
3.5	9.52	9.43
4	9.57	9.57
4.5	9.61	9.63
5	9.65	9.69
5.5	9.68	9.74
6	9.71	9.77
6.5	9.75	9.79
7	9.77	9.83
7.5	9.79	9.86
8	9.82	9.89
8.5	9.84	9.9
9	9.85	9.92
9.5	9.87	9.94
10	9.89	9.96

Table 4.10 0.1MBaNO₃₂ at 29°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.48	6.45
0.5	9.29	7.81
1	9.51	8.55
1.5	9.62	8.94
2	9.7	9.28
2.5	9.77	9.4
3	9.81	9.5
3.5	9.85	9.58
4	9.89	9.66
4.5	9.92	9.7
5	9.94	9.75
5.5	9.97	9.79
6	9.99	9.83
6.5	10.01	9.86
7	10.03	9.89
7.5	10.04	9.91
8	10.06	9.94
8.5	10.07	9.96
9	10.09	9.97
9.5	10.1	9.99
10	10.11	10.01

Table 4.11 0.01MBaNO₃₂ at 29°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.85	7.33
0.5	9.35	8.01
1	9.56	8.64
1.5	9.66	9.09
2	9.74	9.34
2.5	9.79	9.44
3	9.83	9.56
3.5	9.87	9.62
4	9.91	9.7
4.5	9.94	9.74
5	9.96	9.79
5.5	9.99	9.82
6	10.01	9.85
6.5	10.04	9.88
7	10.06	9.9
7.5	10.07	9.92
8	10.08	9.94
8.5	10.1	9.96
9	10.11	9.98

Table 4.12 0.001MBaNO₃₂ at 29°C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.88	6.94
0.5	8.9	7.78
1	9.05	8.34
1.5	9.16	8.87
2	9.24	9.08
2.5	9.34	9.19
3	9.39	9.24
3.5	9.46	9.38
4	9.53	9.46
4.5	9.56	9.51
5	9.6	9.56
5.5	9.63	9.58
6	9.67	9.6
6.5	9.69	9.64
7	9.72	9.67
7.5	9.74	9.7
8	9.76	9.71
8.5	9.78	9.74
9	9.8	9.75

Table 4.13 1MBaNO₃₂ at 35⁰C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	6.72	5.19
0.5	8.28	7.65
1	8.56	8.36
1.5	8.7	8.94
2	8.91	9.06
2.5	9.12	9.24
3	9.3	9.36
3.5	9.68	9.48
4	9.76	9.51
4.5	9.8	9.57
5	9.86	9.61
5.5	9.89	9.64
6	9.92	9.67
6.5	9.94	9.72
7	9.97	9.74
7.5	9.98	9.76
8	10	9.81
8.5	10.02	9.83
9	10.03	9.85
9.5	10.04	9.88
10	10.06	9.91

Table 4.14 0.1MBaNO₃₂ at 35⁰C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.13	5.23
0.5	9.33	5.75
1	9.59	6.03
1.5	9.72	6.13
2	9.78	6.25
2.5	9.85	6.41
3	9.9	6.51
3.5	9.95	6.67
4	9.99	6.8
4.5	10.02	6.94
5	10.06	7.08
5.5	10.09	7.26
6	10.12	7.55
6.5	10.15	7.62
7	10.17	8.7
7.5	10.18	8.95
8	10.2	9.43
8.5	10.22	9.62
9	10.24	9.7
9.5	10.26	9.77
10	10.27	9.82

Table 4.15 0.01MBaNO₃₂ at 35⁰C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	8.74	5.55
0.5	9.51	6.34
1	9.67	6.75
1.5	9.77	7.05
2	9.85	7.6
2.5	9.91	8.45
3	9.96	9.25
3.5	10	9.5
4	10.04	9.7
4.5	10.07	9.78
5	10.1	9.87
5.5	10.12	9.94
6	10.14	9.97
6.5	10.16	10
7	10.18	10.03
7.5	10.2	10.04
8	10.21	10.06
8.5	10.23	10.07
9	10.24	10.09

Table 4.16 0.001MBaNO₃₂ at 35⁰C

0.1 M Vol NaOH	Without TiO ₂	With TiO ₂
0	7.37	5.36
0.5	9.29	7.84
1	9.43	8.63
1.5	9.53	9.02
2	9.6	9.1
2.5	9.68	9.32
3	9.73	9.41
3.5	9.77	9.6
4	9.81	9.63
4.5	9.85	9.65
5	9.88	9.69
5.5	9.91	9.72
6	9.93	9.75
6.5	9.95	9.77
7	9.97	9.77
7.5	9.99	9.8
8	10	9.83
8.5	10.02	9.83
9	10.03	9.85

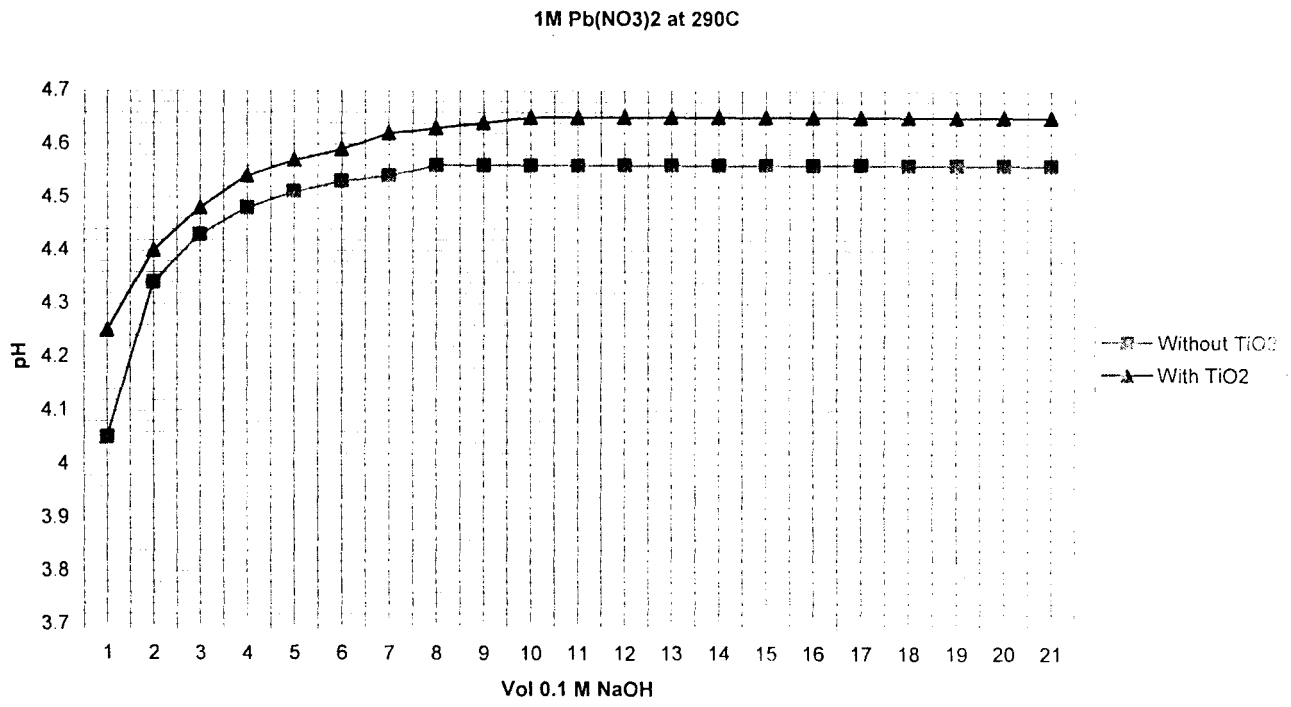


Figure 4.1

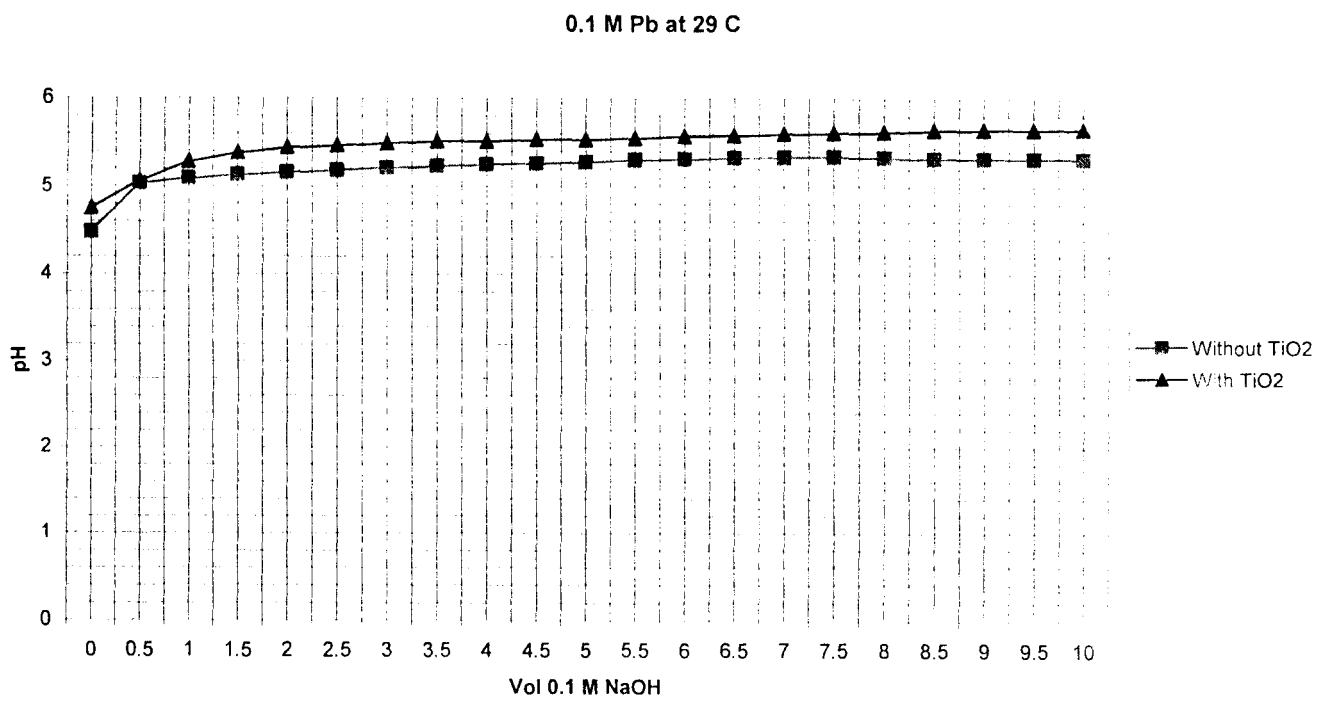


Figure 4.2

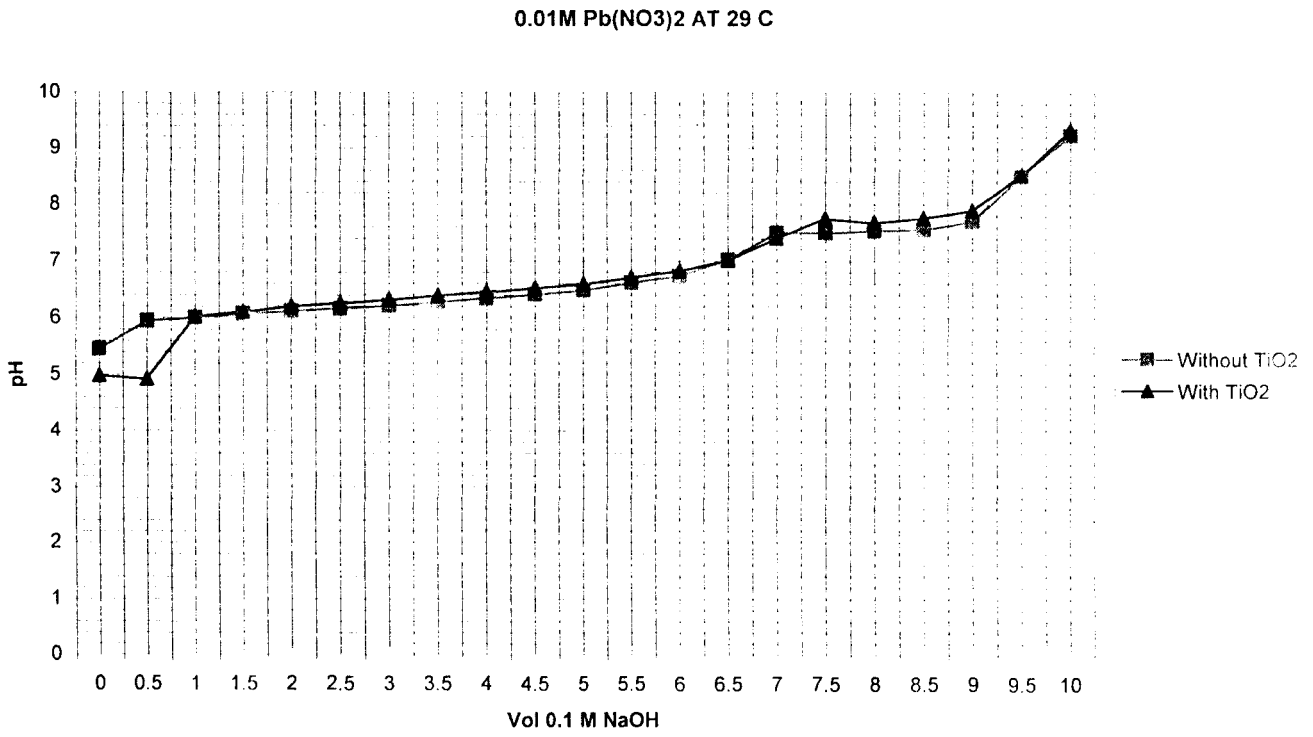


Figure 4.3

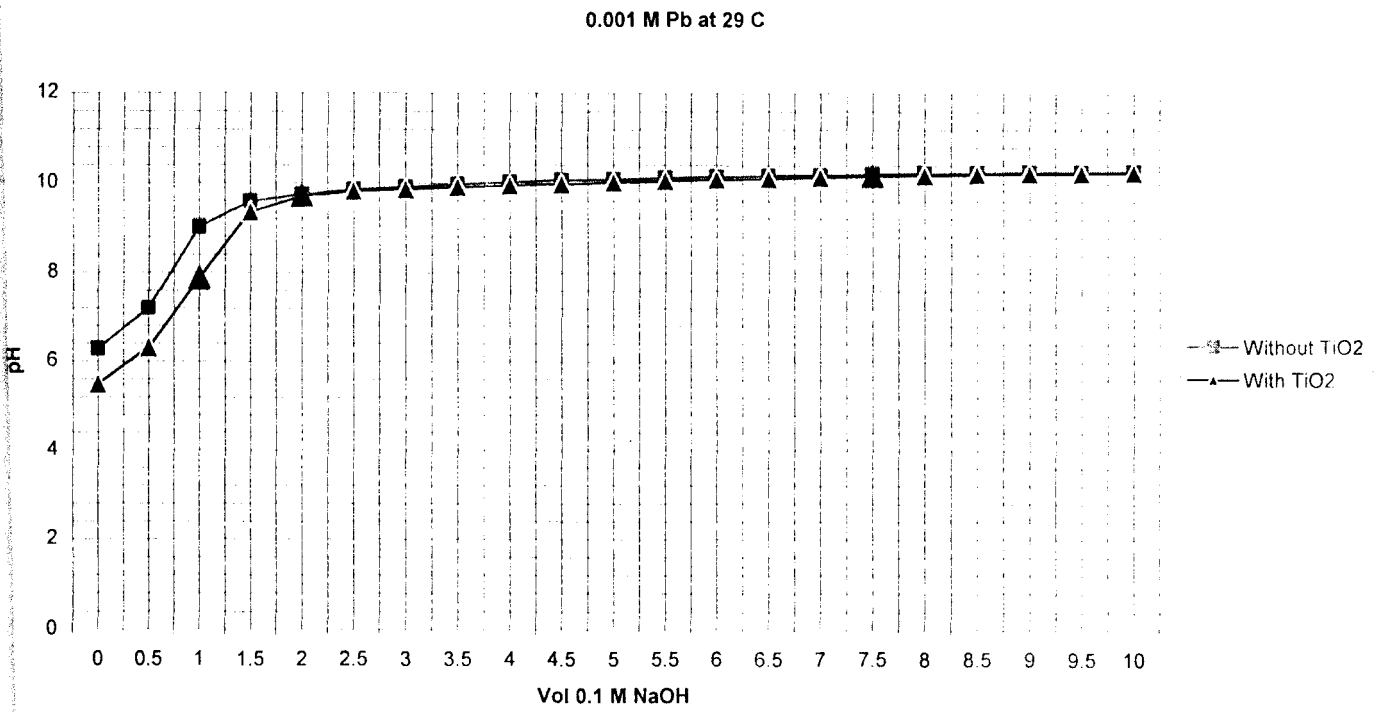


Figure 4.4

0.01 M PbNO₃ at 35 C

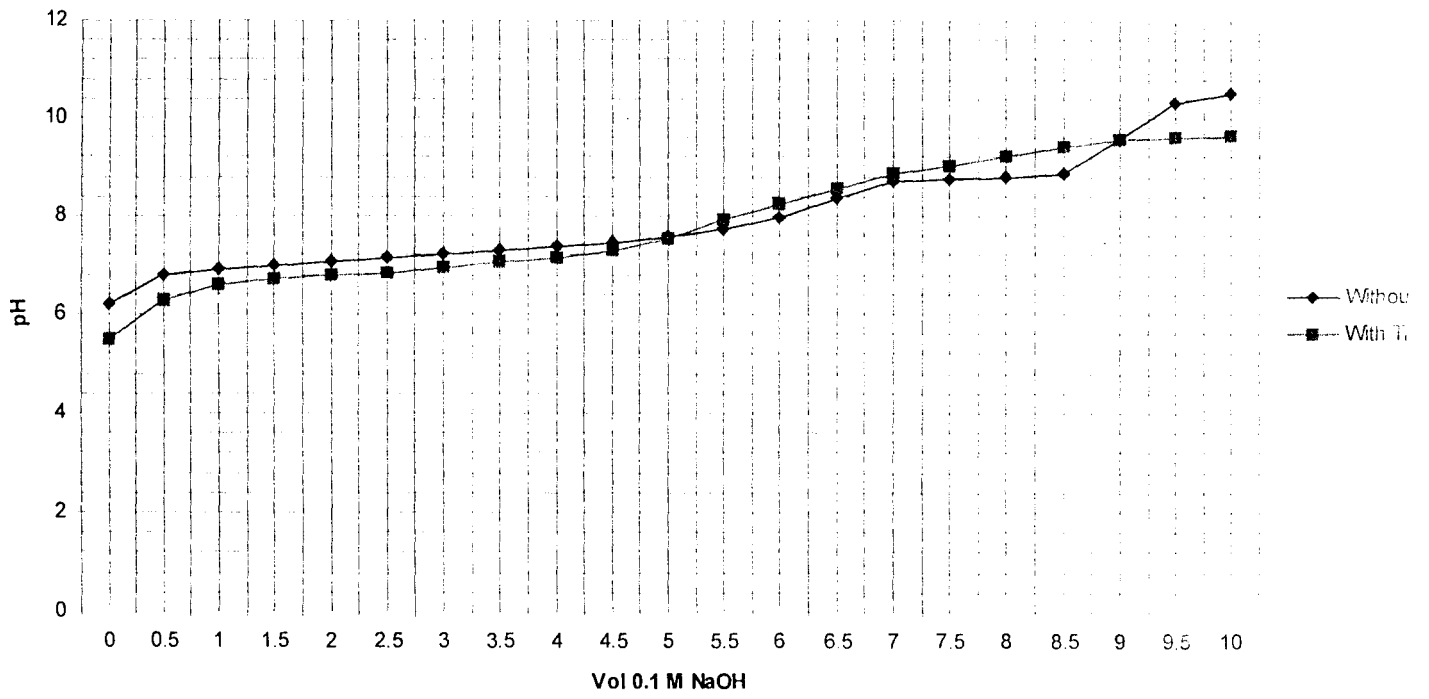


Figure 4.7

0.001M PbNO₃ at 35 C

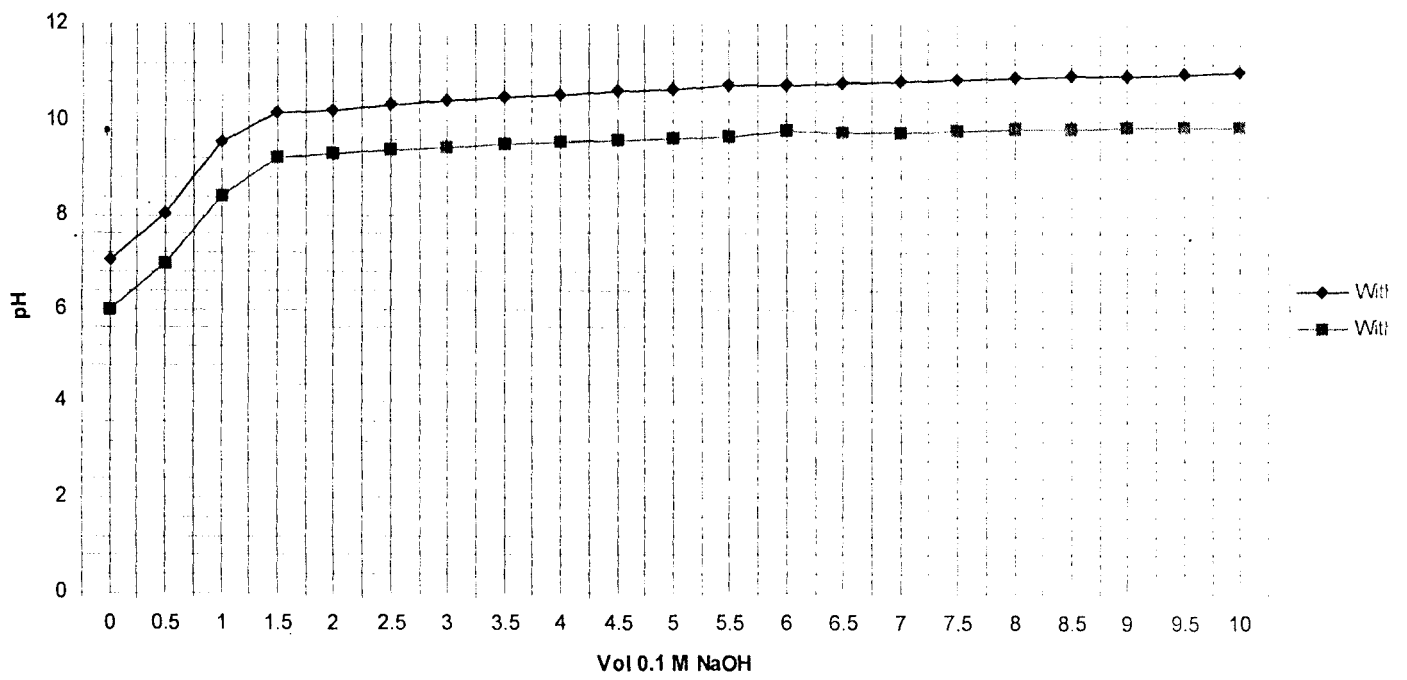


Figure 4.8

0.01 M PbNO₃ at 35 C

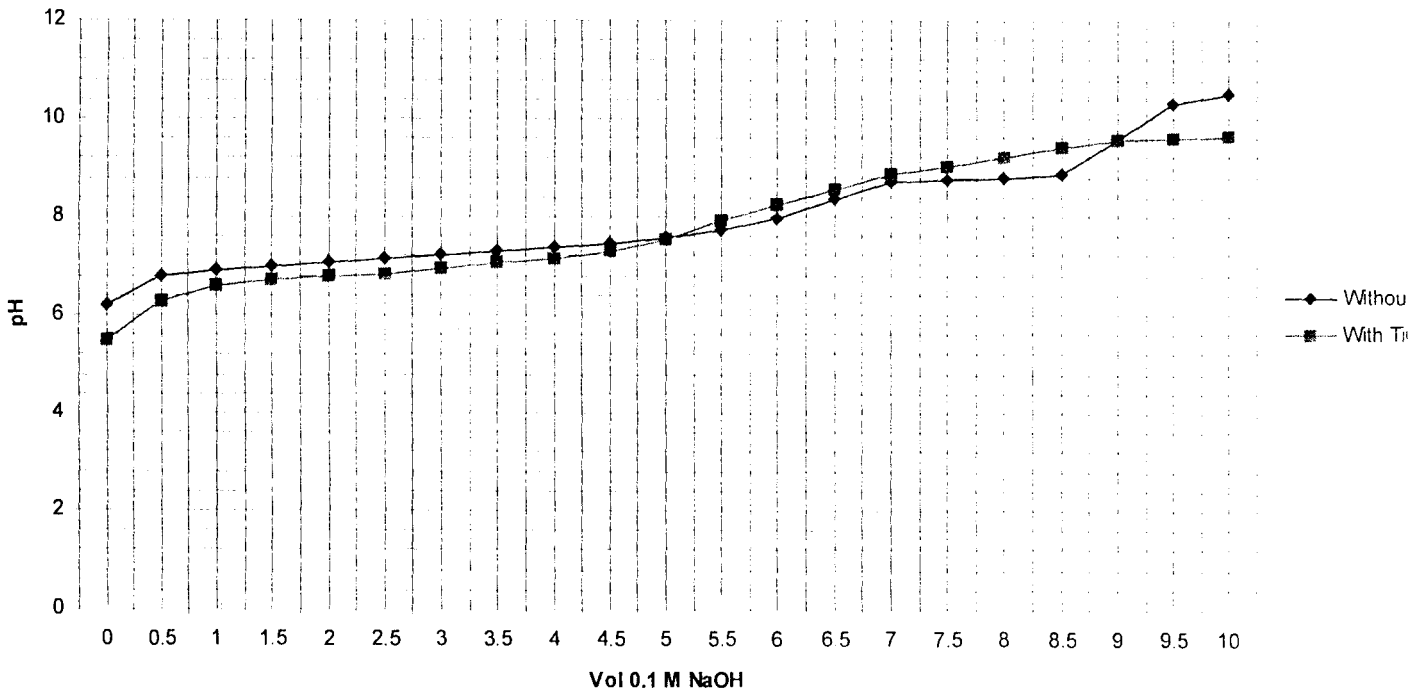


Figure 4.7

0.001M PbNO₃ at 35 C

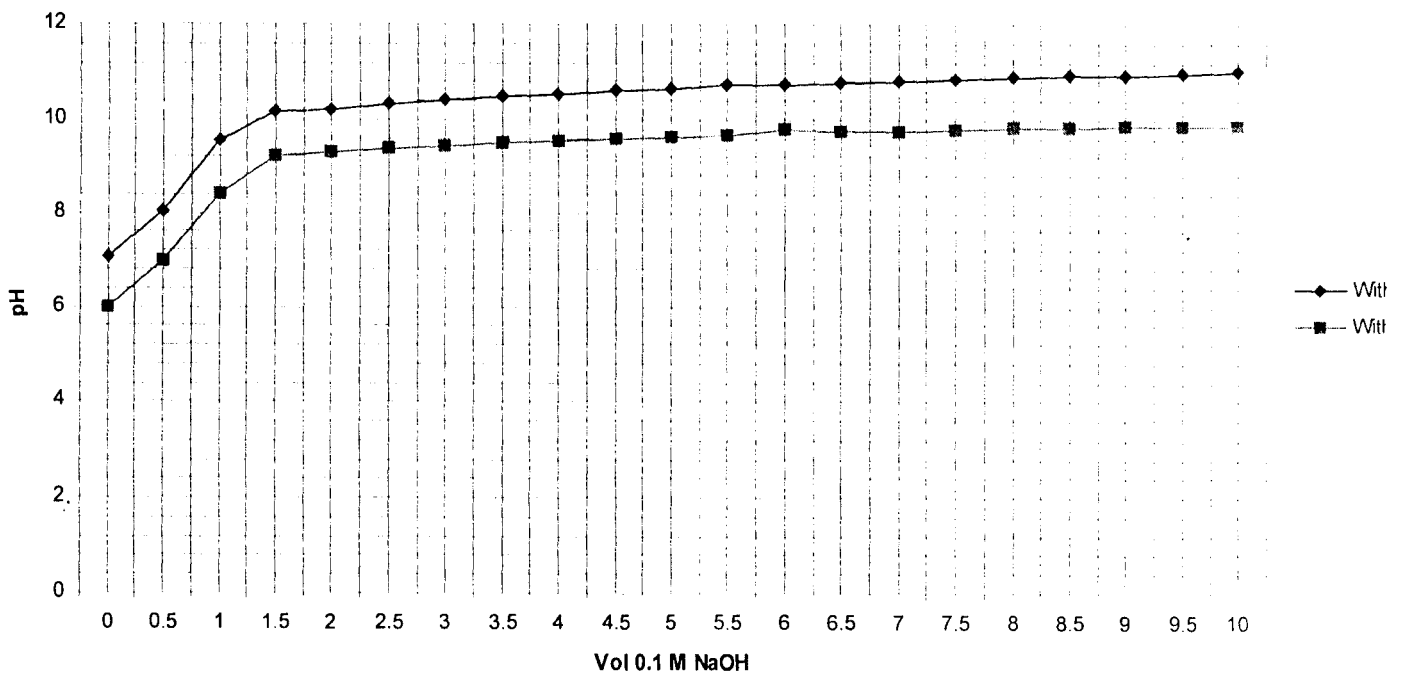


Figure 4.8

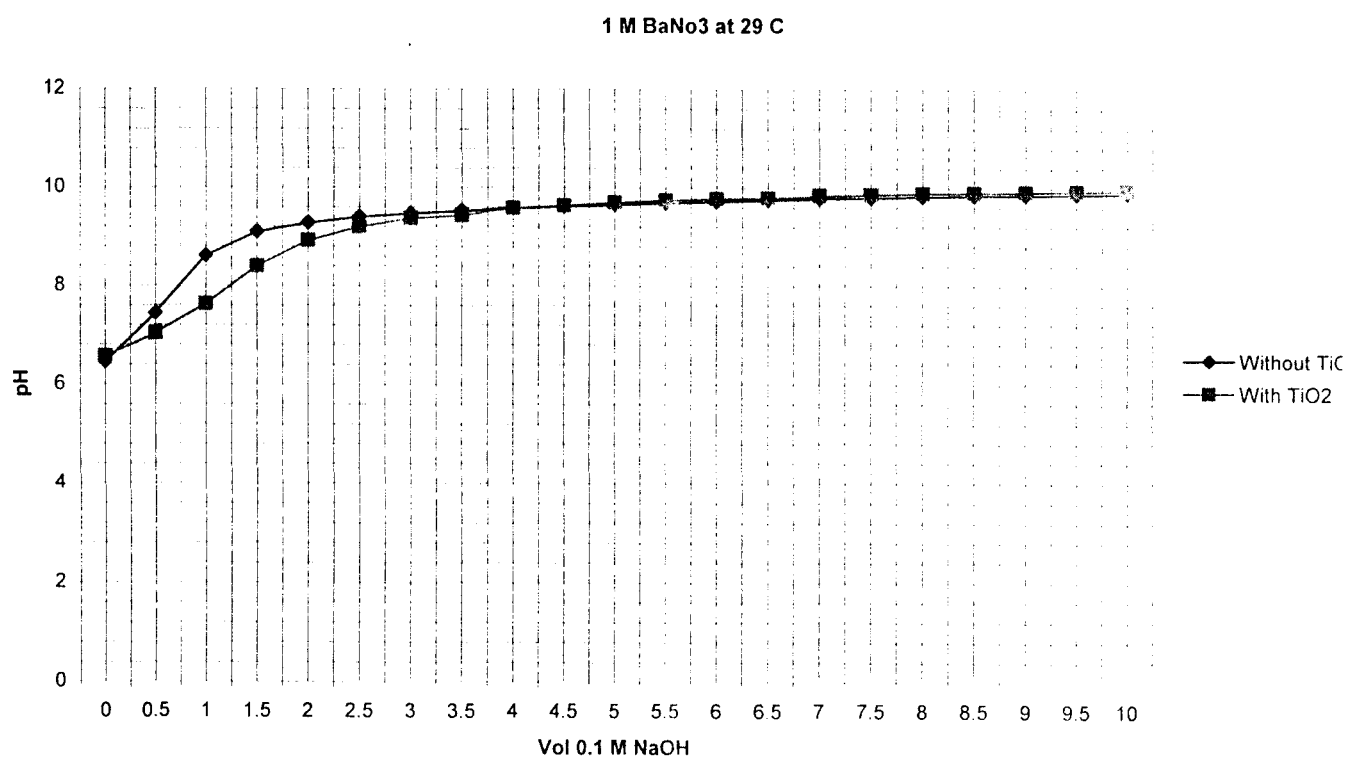


Figure 4.9

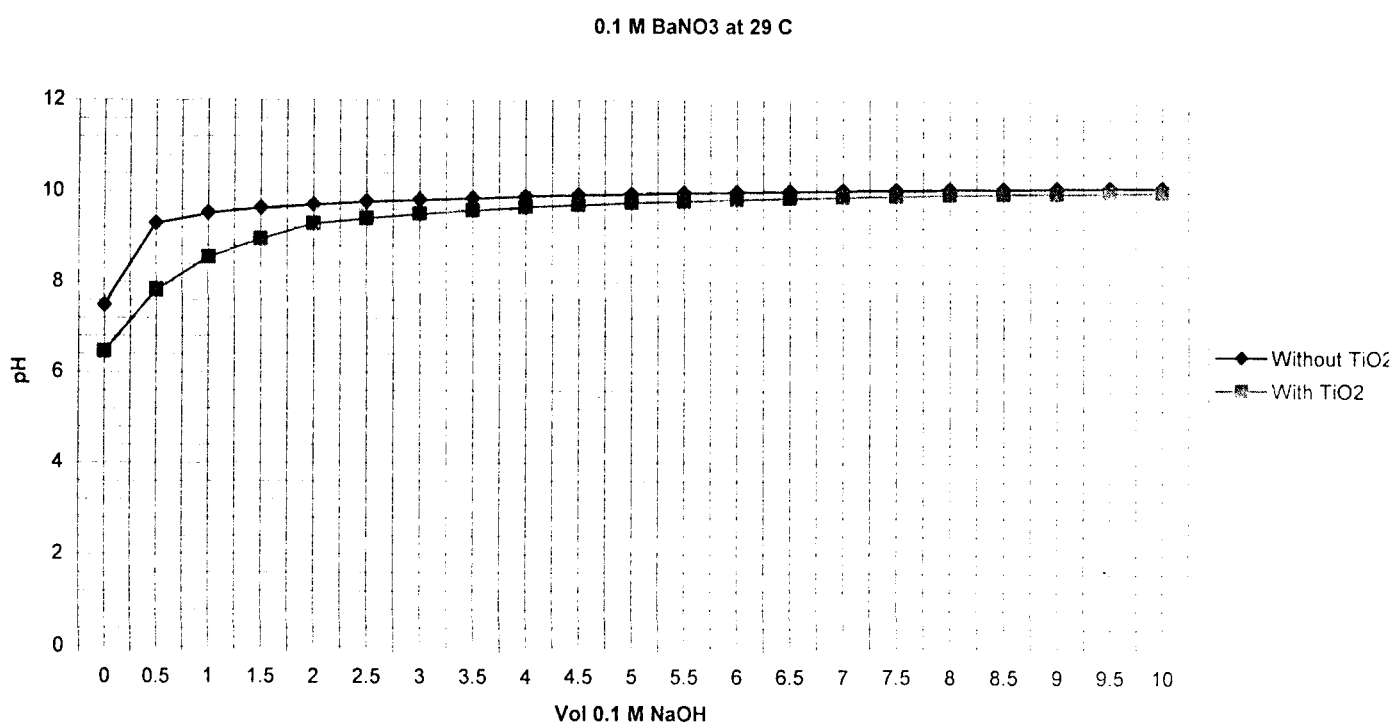


Figure 4.10

0.01 M BaNO₃ at 29 C

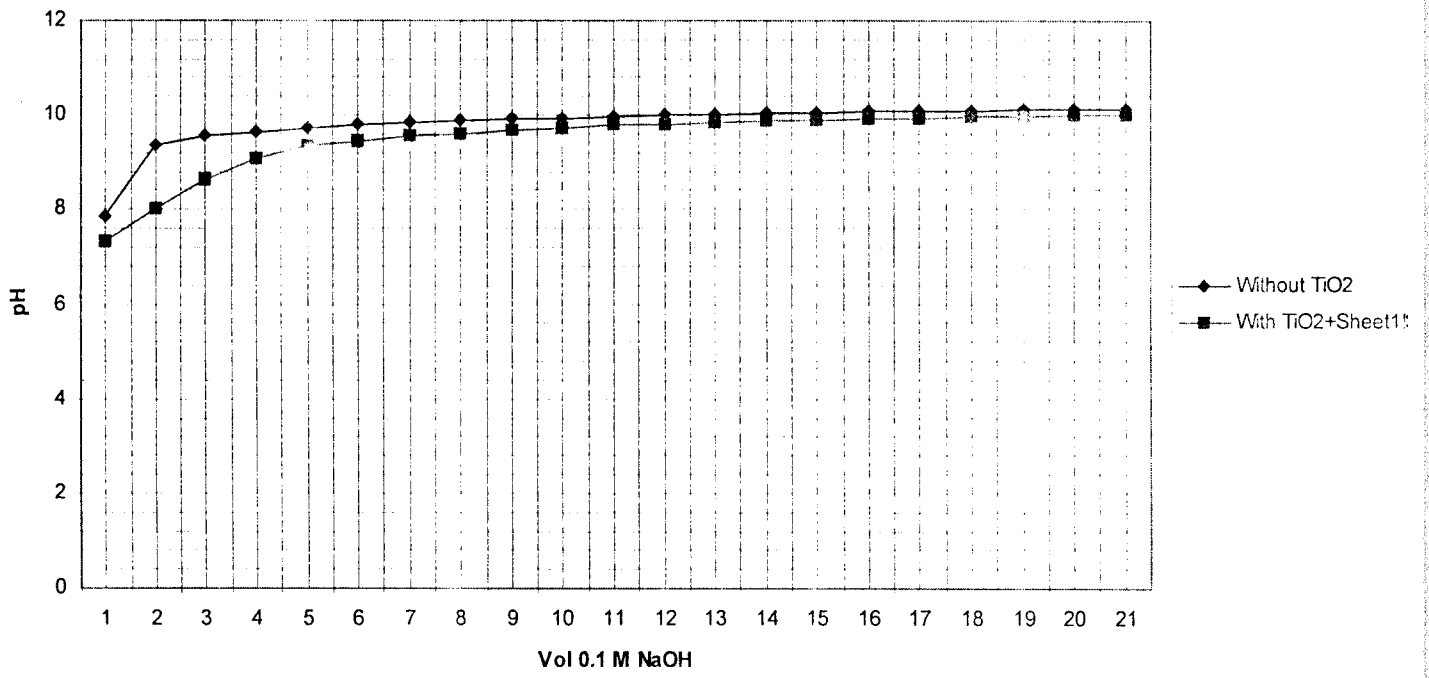


Figure 4.11

0.001 M BaNO₃ at 29 C

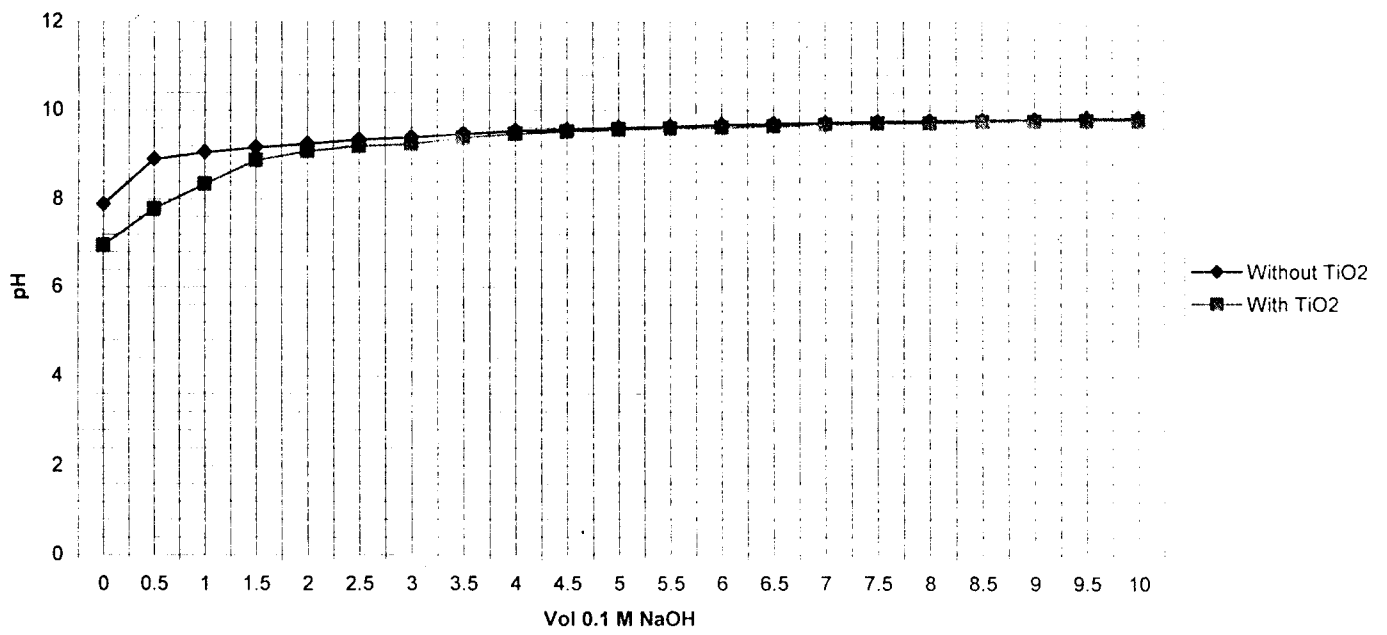
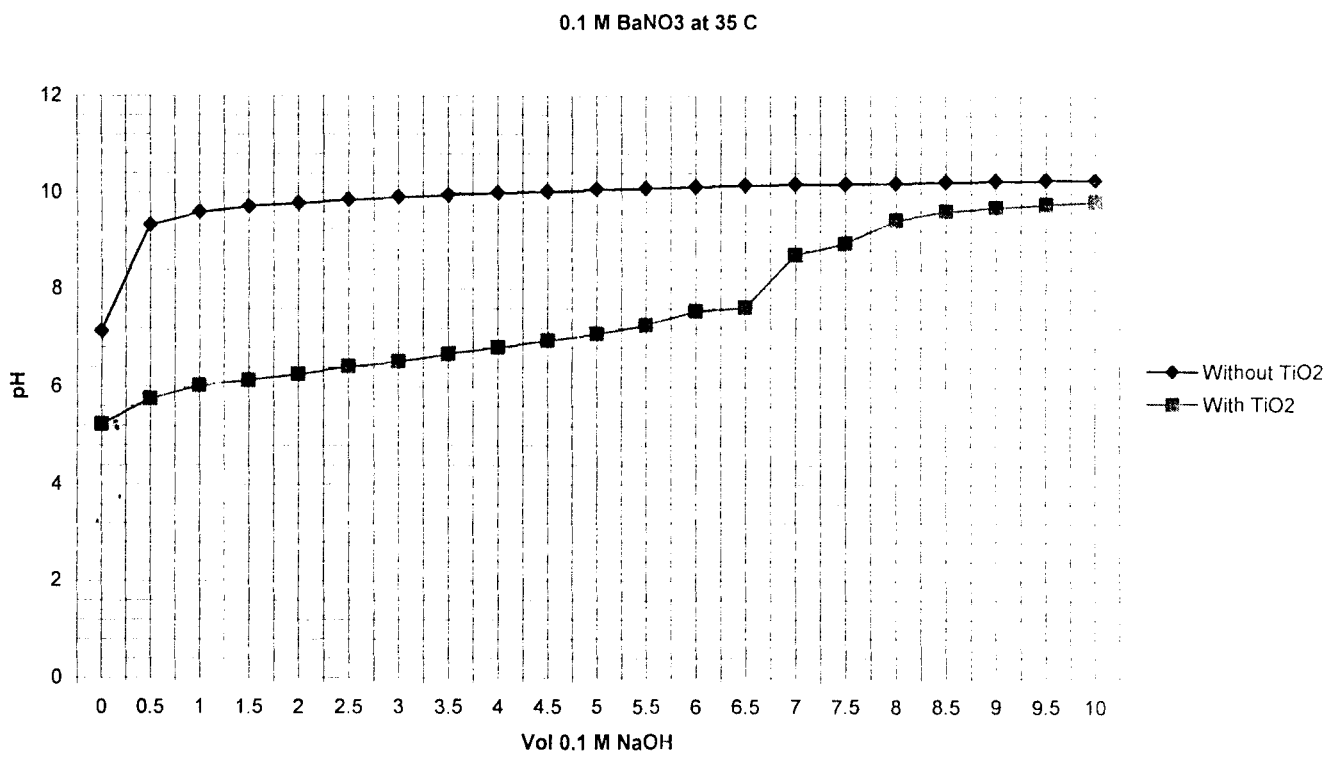
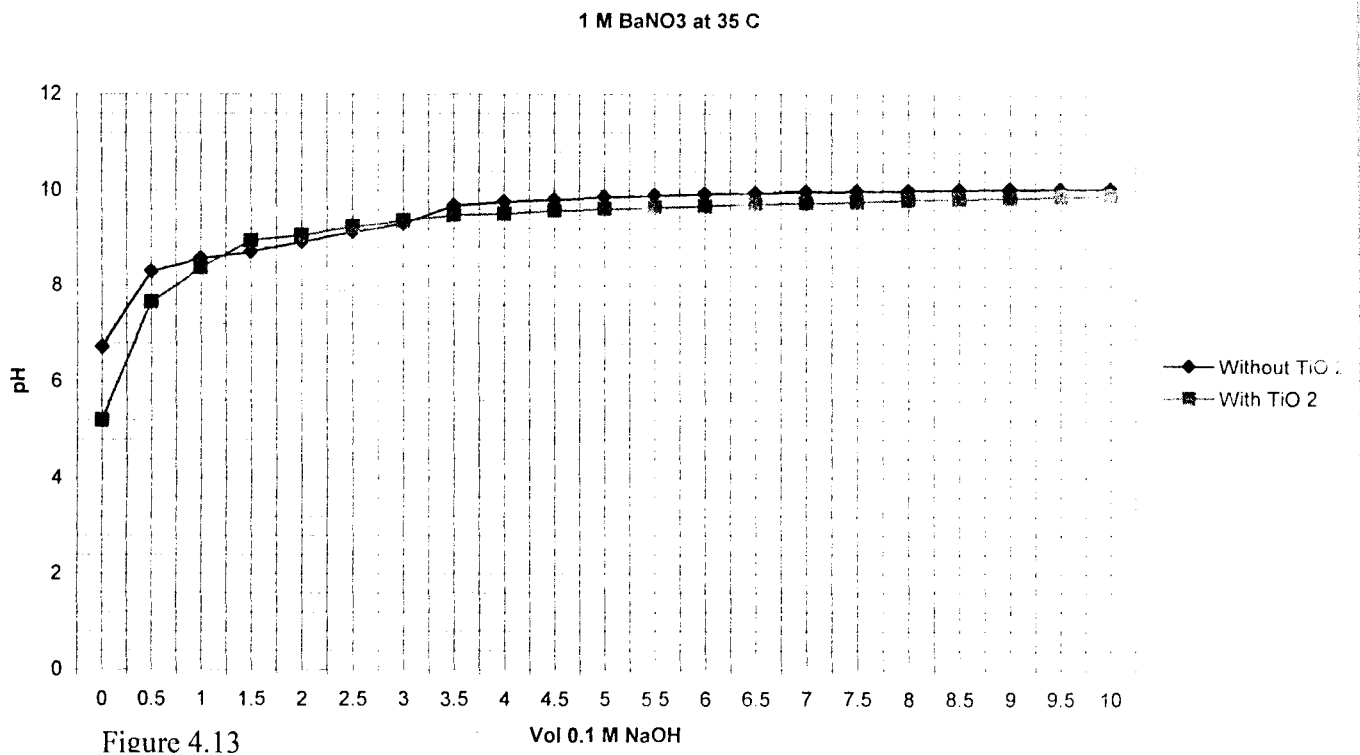


Figure 4.12



0.01 M BaNO₃ at 35 C

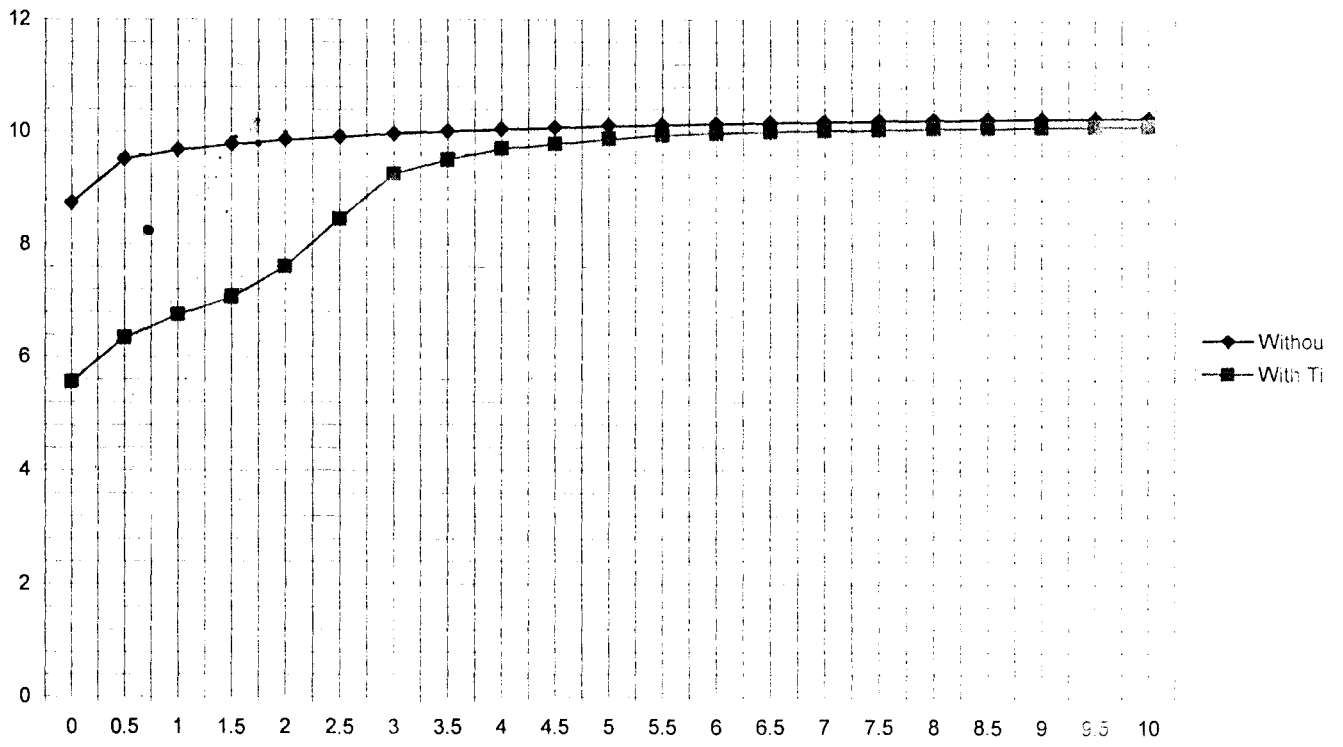


Figure 4.15

0.001 M BaNO₃ at 35 C

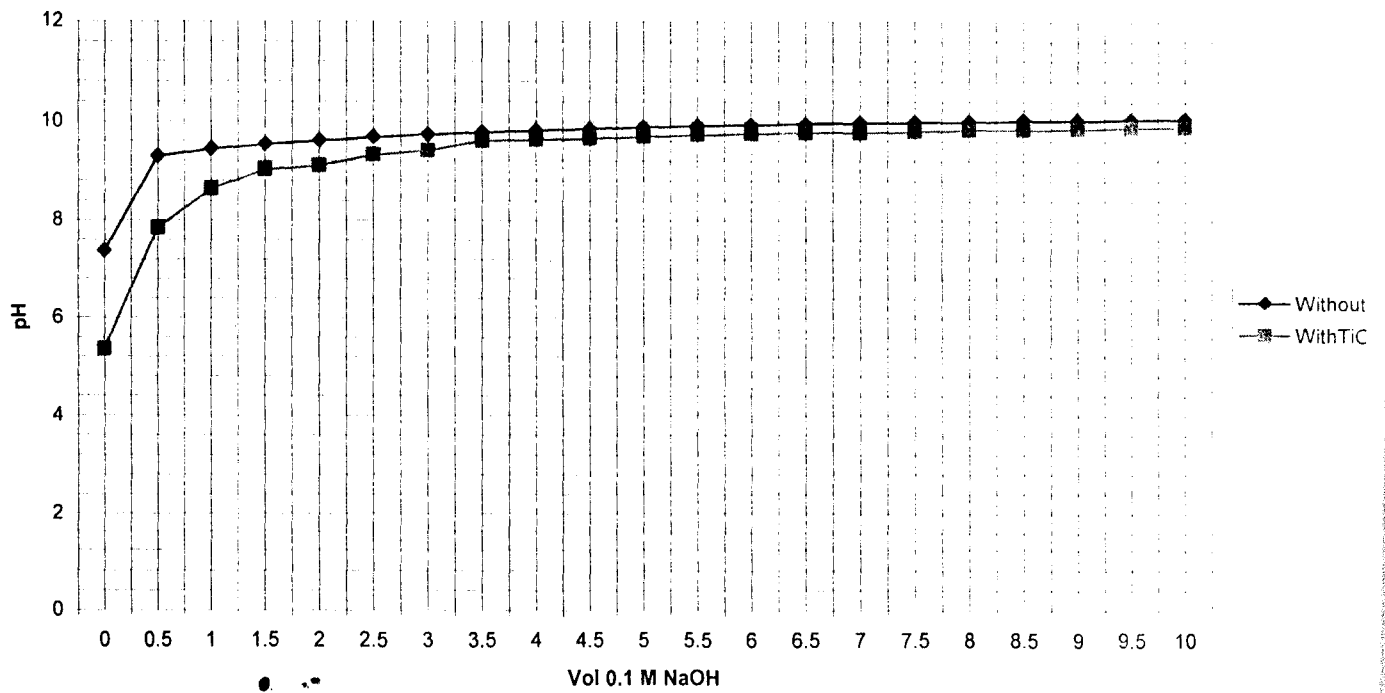


Figure 4.16

Table 4.49:1M pb 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
4.4	0.25	4.2 x10 ⁻¹³	8.11x10 ⁻⁸
4.42	0.3	5.04x10 ⁻¹³	9.73x10 ⁻⁸
4.46	0.3	5.04x10 ⁻¹³	9.73x10 ⁻⁸
4.48	0.4	6.72x10 ⁻¹³	1.3x10 ⁻⁷

Table 4.50:0.1M pb 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
4.8	0.21	3.53x10 ⁻¹³	6.81x10 ⁻⁸
4.9	0.15	2.52x10 ⁻¹³	4.87x10 ⁻⁸
5	0.05	8.40 x10 ⁻¹⁴	1.62x10 ⁻⁸
5.1	0.45	7.6x10 ⁻¹³	1.47x10 ⁻⁷

Table 4.51:0.01M pb 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
5.5	0.16	2.69x10 ⁻¹³	5.19x10 ⁻⁸
6	0.05	8.4x10 ⁻¹⁴	1.62x10 ⁻⁸
6.5	0.15	1.26x10 ⁻¹²	2.43x10 ⁻⁷
7	0.2	3.36x10 ⁻¹⁴	6.49x10 ⁻⁹

Table 4.52:0.001M pb 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
7	0.3	5.04×10^{-13}	9.73×10^{-8}
8	0.35	5.88×10^{-13}	1.14×10^{-7}
9	0.3	5.04×10^{-13}	9.73×10^{-8}
10	0.02	3.36×10^{-14}	6.49×10^{-7}

Table 4.53:1M pb 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
4.6	0.8	1.34×10^{-13}	2.59×10^{-8}
4.8	0.65	1.09×10^{-12}	2.10×10^{-7}
5	1.3	2.18×10^{-12}	4.21×10^{-7}
5.2	0.9	1.51×10^{-12}	2.91×10^{-7}

Table 4.54:0.1M pb 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
5.4	0.36	6.04×10^{-13}	1.17×10^{-7}
5.6	2.1	3.53×10^{-12}	6.81×10^{-7}
5.8	2.99	5.02×10^{-12}	9.69×10^{-7}
6	0.45	7.56×10^{-13}	1.47×10^{-7}

Table 4.55:0.01M pb 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
6.5	0.55	9.24x10 ⁻¹³	1.78x10 ⁻⁷
7	1.8	3.02x10 ⁻¹²	5.83x10 ⁻⁷
7.5	0.15	2.52x10 ⁻¹³	4.87x10 ⁻⁸
8	0.45	7.56x10 ⁻¹³	1.47x10 ⁻⁷

Table 4.56:0.001M pb 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
8	0.4	6.72x10 ⁻¹³	1.3x10 ⁻⁷
8.5	0.45	7.56x10 ⁻¹³	1.47x10 ⁻⁷
9	0.5	8.4x10 ⁻¹³	1.62x10 ⁻⁷
9.5	2.55	4.28x10 ⁻¹²	8.26x10 ⁻⁷

Table 4.57:1M Ba 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
7	0.1	1.68x10 ⁻¹³	3.24x10 ⁻⁸
7.5	0.35	5.88x10 ⁻¹³	1.14x10 ⁻⁷
8	0.5	8.4x10 ⁻¹³	1.62x10 ⁻⁷
8.5	0.75	1.26x10 ⁻¹²	2.43x10 ⁻⁷

Table 4.58:0.1M Ba 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
8	0.43	7.22x10 ⁻¹³	1.39x10 ⁻⁷
8.5	0.65	1.09x10 ⁻¹²	2.1x10 ⁻⁷
9	1.2	2.02x10 ⁻¹²	3.9x10 ⁻⁷
9.5	0.68	1.14x10 ⁻¹²	2.2x10 ⁻⁷

Table 4.59:0.01M Ba 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
8	0.4	6.72x10 ⁻¹³	1.3x10 ⁻⁷
8.5	0.55	9.24x10 ⁻¹³	1.78x10 ⁻⁷
9	1.02	1.71x10 ⁻¹²	3.3x10 ⁻⁷
9.5	2	3.36x10 ⁻¹²	6.49x10 ⁻⁷

Table 4.60:0.001M Ba 2+ at 29 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm2)
8	0.5	8.4x10 ⁻¹³	1.62x10 ⁻⁷
8.5	0.85	1.43x10 ⁻¹²	2.76x10 ⁻⁷
9	0.95	1.60x10 ⁻¹²	3.09x10 ⁻⁷
9.5	0.5	8.4x10 ⁻¹³	1.62x10 ⁻⁷

Table 4.61:1M Ba 2+ at**35 0c**

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm ²)
7	0.23	3.86x10 ⁻¹³	7.45x10 ⁻⁸
7.5	0.15	2.52x10 ⁻¹³	4.87x10 ⁻⁸
8	0.3	5.02x10 ⁻¹³	9.73x10 ⁻⁸
8.5	0.3	5.04x10 ⁻¹³	9.73x10 ⁻⁸

Table 4.62:0.1M Ba 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm ²)
7.5	2.05	3.44x10 ⁻¹²	6.64x10 ⁻⁷
8	2.3	3.86x10 ⁻¹²	7.45x10 ⁻⁷
8.5	2.4	4.03x10 ⁻¹²	7.78x10 ⁻⁷
9	2.75	4.62x10 ⁻¹²	8.92x10 ⁻⁷

Table 4.63:0.01M Ba 2+ at 35 0c

PH	change in volume (DV)	Adsorption(D)	Electric charge(E=nxf.D Cgmole/cm ²)
9	2.55	4.28x10 ⁻¹²	8.26x10 ⁻⁷
9.2	2.6	4.37x10 ⁻¹²	8.43x10 ⁻⁷
9.4	3	5.04x10 ⁻¹²	9.73x10 ⁻⁷
9.6	3	5.04x10 ⁻¹²	9.73x10 ⁻⁷

CHAPTER FIVE

5.0 DISCUSSION OF RESULT

5.11 EFFECT OF CONCENTRATION ON pH

During titration, as titrant (NaOH) is being titrated into the solution of Lead (II) nitrate or Barium (II) nitrate, for each titration, at an interval of 2 minutes, it was observed that there was an increase in pH showing that the solution was becoming more basic. The titration done for both with and without Titanium (iv) oxide (TiO_2), at different concentrations showed an increase in pH.

For the first solution, Lead (II) nitrate $\{\text{Pb}(\text{NO}_3)_2\}$, as 0.5ml of NaOH is being poured into the solution at an approximate time interval, there is an appreciable increase in the pH. But with progressive increase in the NaOH, the size of increase in pH is negligible or there is no change at all. For titrations with TiO_2 the same trend occurs as that without TiO_2 , only that with TiO_2 at concentrations of 1M and 0.1M for $\{\text{Pb}(\text{NO}_3)_2\}$, the solution is less acidic at the end of the titration, but for all the other concentrations of the solutions, ($\text{Pb}(\text{NO}_3)_2$ and $\text{Ba}(\text{NO}_3)_2$), titrated, with TiO_2 was less basic than without it. Also, it was deduced from the titrations that the lower the concentration, the more basic the results turned out to be, $0.001\text{M} > 0.01\text{M} > 0.1\text{M} > 1\text{M}$, that is the results for 0.001M concentration are more basic than those of 0.1M, and those of 0.1M are more basic than those of 0.01M.

The results of the two solutions, followed the same trend, only that the results of Barium (II) nitrate turned out more basic than the results of Lead (II) nitrate.

5.2.0 DISCUSSION OF RESULT ON Pb^{2+}

5.2.1 EFFECT OF CONCENTRATION ON CHARGE FOR Pb^{2+}

From the results tabulated, in which charge was calculated, it could be deduced that as the concentration of Pb^{2+} is reduced, there is an increase in the charge.

5.22 EFFECT OF TEMPERATURE ON CHARGE FOR Pb^{2+}

At both temperatures of 29.2°C and 35°C the effect of temperature on charge was deduced and it showed that an increase in temperature led to an increase in the charge.

5.3.0 DISCUSSION OF RESULTS ON Ba^{2+}

5.3.1 EFFECT OF CONCENTRATION ON CHARGE FOR Ba^{2+}

From the tabulated results, in which charge was calculated, reduction in the concentration of the Ba^{2+} most of the time led to an increase in the charge except in 0.001M concentration at 35°C.

5.32 EFFECT OF TEMPERATURE ON CHARGE FOR Ba^{2+}

The effect of temperature on the charge of Ba^{2+} could be expressed in a linear form, where an increase in the temperature of Ba^{2+} leads to an increase in the charge.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1.0 Conclusion

Charge is directly proportional to voltage, meaning that as charge increases, voltage also increase. Since voltage output determines the life span of a dry cell, it goes a long way to say that an increase in charge increases the lifespan of the dry cell. The analysis done were used to calculate charge and to relate concentration and temperature to charge which have adverse effect on the life span of the dry cell, shows that a reduction in the concentration and an increase in the temperature results to an increase in the charge which is the voltage output, but slight deviations occur in certain cases.

From results it shows that TiO_2 has an effect on the results obtained in which titration results are less basic than those without TiO_2 . This has proven TiO_2 to be used as a depolarizer. The ions (Pb^{2+} and Ba^{2+}) which when blended with TiO_2 improves on the function of TiO_2 as a depolarizer. The presence of (Pb^{2+} and Ba^{2+}) increases surface charge, which effects voltage output and extends cells life span. From the tabulated results, the highest surface charge (0.973) is produced at pH 9.4 to 9.6, temperature of 35°C , using 0.01M Ba^{2+} ; this implies that thhe highest voltage output based on this analysis is produced at this temperature, concentration and pH, in which TiO_2 is most effective as depolarizer in the dry cell.

6.2.0 RECOMMENDATION

Based on the analysis and results obtained, the following recommendations are;

1. More equipment concerning this analysis should be gotten by the department so that other methods can be used to attain more accurate results.

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2. The titration in which the direct measurement of the voltage is done should also be considered for diversity analysis.

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APPENDIX A

- 1) Preparation of 1,0.1,0.01,0.001M concentration of $\text{Pb}(\text{NO}_3)_2$, this was done first by calculating the molar mass of $\text{Pb}(\text{NO}_3)_2$, which was calculated to be 331.2g/mol. Thus, 1M solution of $\text{Pb}(\text{NO}_3)_2$ contains 331.2g/mol of the solid in 1000ml of distilled water. 0.1M solution of $\text{Pb}(\text{NO}_3)_2$ will contain 33.12g/mol of the solid in 1000ml of distilled water. 0.01M solution of $\text{Pb}(\text{NO}_3)_2$ contains 3.312g/mol of the solid in distilled water, while in 0.001M solution of $\text{Pb}(\text{NO}_3)_2$, it contains 0.3312g/mol of the solid in distilled water.
- 2) Preparation of 1,0.1,0.01,0.001M concentration of $\text{Ba}(\text{NO}_3)_2$; this was done by first calculating the molar mass of $\text{Ba}(\text{NO}_3)_2$, which was calculated to be 261.3g/mol. Thus, 1M solution of $\text{Ba}(\text{NO}_3)_2$ contains 261.3g/mol of the solid in 1000ml of distilled water. 0.1M solution of $\text{Ba}(\text{NO}_3)_2$ contains 26.13g/mol of the solid in 1000ml of distilled water. 0.01M solution of $\text{Ba}(\text{NO}_3)_2$ contains 2.613g/mol of the solid in 1000ml of distilled water, while 0.001M solution of $\text{Ba}(\text{NO}_3)_2$ contains 0.2613g/mol of the solid in 1000ml of distilled water.

APPENDIX B

CALCULATIONS INVOLVED IN THE DETERMINATION OF SURFACE AREA OF TiO₂ BY ADSORPTION FROM SOLUTION METHOD.

i) To calculate the concentration C of acetic acid given

$$\text{Percentage purity (\%P)} = 99\%$$

$$\text{Specific Gravity (S.G)} = 1.048$$

$$\text{Molar mass (m.m)} = 60.05$$

$$C = \frac{\%P \times \text{S.G} \times 1000}{60.05 \times 100} = 17.28$$

Hence C = 17.28m

ii) To calculate the volume of acid (ml) needed for 1000cm³ of 0.15m

$$\text{Where } M_1 = 0.15$$

$$V_1 = 1000\text{cm}^3 \text{ (ml)}$$

$$M_2 = 17.28\text{ml}$$

$$V_2 = ?$$

From Dilution Law:

$$M_1V_1 = M_2V_2 \text{ -----Eqn 1}$$

$$V_2 = \frac{M_1V_1}{M_2} \text{ -----Eqn 2}$$

$$M_2$$

$$V_2 = \frac{0.15 \times 1000}{17.28} = 8.68 \text{ml}$$

17.28

80, 60, 40, 20 and 10ml of 0.15 were made as to 100ml with distilled water to get 0.12, 0.09, 0.03, 0.15m respectively

iii) calculating the concentration left after adsorption (final concentration).

Let the final (equilibrium) concentration of acetic acid M_1

Volume of acetic acid $V_1 = 25 \text{ml}$ (constant)

Concentration of NaOH $M_2 = 0.1 \text{M}$

Final Volume of NaOH = V_2

From

$$M_1 V_1 = M_2 V_2 \text{-----} 1$$

$$M_1 = \frac{M_2 V_2}{V_1} \text{-----} 2$$

Substituting values from table 1 into eqn 2 gives final concentration for the initial 0.15m sample.

$$M_1 = \frac{0.1 \times 47.05}{25} = 0.1882$$

25

Final concentration for the initial 0.12m sample

$$M_1 = \frac{0.1 \times 40.92}{25} = 0.1637$$

25

Final concentration for the initial 0.09m sample

$$M1 = \frac{0.1 \times 30.52}{25} = 0.1221$$

25

Final concentration for the initial 0.06m sample

$$M1 = \frac{0.1 \times 20.25}{25} = 0.081$$

25

Final concentration for the initial 0.03m sample

$$M1 = \frac{0.1 \times 11.36}{25} = 0.0454$$

25

Final concentration for the initial 0.015m sample

$$M1 = \frac{0.1 \times 7.64}{25} = 0.0306$$

25

Final concentration for the initial 0.03m (make up volume)

$$M1 = \frac{0.1 \times 0.35}{25} = 0.018$$

25

iv) Calculating the slope from graph C/N against C (Fig. 1)

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{4.70 - 3.0}{0.160 - 0.08} = \frac{1.7}{0.08}$$

$$\text{Slope} = 21.25$$

But from theory, equation 2 page-----

$$C/N = C/Nm + 1/KNm$$

$$y = mx + c$$

$$m = 1/Nm = \text{slope} = 21.25$$

Therefore $N_m = 1/21.25 = 0.0471$

v) Calculating of specific area A

Specific area of adsorption, A (in square meters per gram) is given by

$$A = N_m N_o \delta \times 10^{-20}$$

Where N_m – number of adsorption sites (0.0471)

N_o – Avogadro's number (6.023×10^{23})

δ – Area occupied by adsorbed molecules on the surface = 21×10^{-20}

Therefore upon substitution

$$A = 0.0471 \times 6.023 \times 10^{23} \times 21 \times 10^{-20}$$

$$= 5957.35 \text{ m}^2/\text{g}$$

$$\text{or} = 59573493 \text{ cm}^2/\text{g}$$