– **Table of Contents**

– CONTENTS

Water Splitting Experiment

Electrolysis of water (H_2O)

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I. Introduction

This experiment aims to study the electrolysis of water. It is a process by which chemical reaction is carried out by using electric current. That is, it is the conversion of electrical energy into chemical energy. In water electrolysis, water is oxidized at the anode (negative) to produce oxygen and reduced at the cathode (positive) to produce hydrogen. Hydrogen is used to power fuel-cell cars and trucks. Electrolysis is one of the cheapest and cleanest ways to produce pure hydrogen gas.

In the experiment, we also compare the volume of hydrogen gas obtained by using Distilled water,Tap water and after using Electrolytes such as $NaCl$ and $MgCl_2$. This was done to prove that the efficiency of the water electrolysis highly depends on the electrodes and the electrolytes used in this process.

The reaction taking place at the cathode and anode are as follows

Anode: $2\,H_2O(l) \longrightarrow O_2(g) + 4\,H^+(aq) + 4\,e^-$ V=-1.23V
Cathode: $2\,H_2O(l) + 2\,e^- \longrightarrow H_2(g) + 2\,OH^-(aq)$ V=-0.83V
Overall: $2\,H_2O \longrightarrow 2\,H_2 + O_2$

II. Materials

A. Chemicals

1) Tap Water
2) Distilled(deionised) Water
3) $MgCl_2$ solution
4) $NaCl$ solution

B. Apparatus

1) Battery($9V$)
2) Beaker
3) Rubber bulb
4) Foam to hold the burette
5) 2 Graduated burettes
6) Copper wire
7) Stopwatch

III. Safety Measures

1) Make sure that the electrodes are completely immersed in water
2) Make sure that there is no room for the bubbles to go out of the burettes
3) Burettes should not touch the base of the container
4) Handle all the apparatus with care
5) Wear gloves and eyeglasses while working in the lab

IV. Procedure

1) Connect the electrodes to the power source($9V$).$Placetheelectrodesinadeionizedwater - filledinvertedburetteinaBeaker, carefullyensuringtheelectrode$
2) Apply voltage to initiate electrolysis. Hydrogen gas should evolve at the cathode (negative electrode), while oxygen gas should evolve at the anode (positive electrode).
3) The gases should be collected at the top of the inverted measuring cylinders.
4) Repeat the procedure with tap water, $1M\ NaCl$ solution, and $1M\ MgCl_2$ solution.
5) Preparation of $NaCl$ and $MgCl_2$ solutions:
6) Prepare $1M$solution of $NaCl$ and $MgCl_2$ by dissolving $58.44g$ of $NaCl$ and $95.21g$ of $MgCl_2$ in $1L$ of deionized water, respectively. Dissolve $15 - 20mL$ of $1M$ solution into $150mL$ of deionized water to make an electrolyte solution.

V. Observations and Results

A. Distilled(deionized) water

No bubbles were observed in the electrolysis of deionized water. This is due to the absence of ions, which conduct electrolysis and lead to the breakdown of water.

B. Tap Water

A slight amount of bubbles were observed in the electrolysis of tap water. This is due to the dissolved minerals and ions which act as ions, thus improving the conductance. However, the number of bubbles is less than that obtained in the solution with added electrolytes.

C. Sodium Chloride ($NaCl$)

Sodium chloride contains sodium ions(Na^+) and chloride ions(Cl^-), which helps increase the solution's electrolytic efficiency. Therefore, more Hydrogen(H_2) is produced at the cathode as compared to the distilled and the tap water but is less as compared to the Magnesium Chloride solution

D. Magnesium Chloride ($MgCl_2$)

Magnesium Chloride contains Magnesium(Mg^+2) and 2 Chloride ions(Cl^-). Due to more charge on the Magnesium ions, the electrolytic efficiency has been increased as compared to Na^+ ions, which results in more amount of Hydrogen gas (H_2) being formed at the cathode.

We can see the graph of the Volume of H_2 seen at the cathode with respect to time.

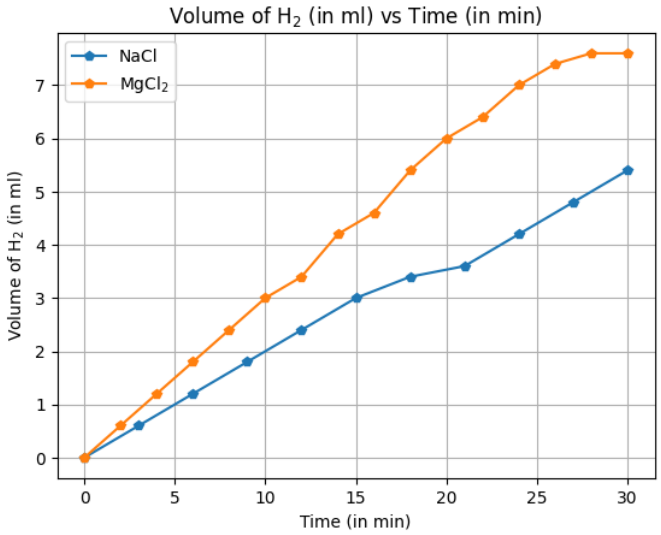


Fig. 1: Volume of $H_2(inml)$ vs $Time(inmin)$

If we had taken the readings for more amount of time, we would have observed a flat straight line after some time because the electrolysis might have reached the state of dynamic equilibrium at that time.

It is also observed that the number of bubbles seen at the cathode is greater than that of the anode. The reason is the stoichiometric ratio of H_2 and O_2, which is 2:1 by volume. So, we observe more amount of bubbles at the cathode.

VI. Conclusion

In this experiment, we compared the efficiency of electrolysis when using deionised water, tap water and two alternative electrolytes, $NaCl$ and $MgCl_2$, to see how well water electrolysis produced hydrogen gas. It was concluded that the volume of hydrogen produced is negligible for deionized water and very little for tap water; however the electrolytes produced a significant volume of hydrogen.
This indicates that the effectiveness of water electrolysis is increased by electrolytes, making the separation of hydrogen and oxygen gasses easier. It was also shown that $MgCl_2$ produced more hydrogen than $NaCl$.This can be explained by the varied characteristics of the electrolytes, such as their conductivity and ion concentration, which affect the rate of electrolysis and may cause this efficiency variance. The colour of the solution with $MgCl_2$ as an electrolyte turned yellow due to the oxidation of chloride ions.
Thus, it was concluded that by adding electrolytes, the efficiency of the electrolysis can be increased and can used to produce Hydrogen to power fuel cells.

VII. Author Contributions

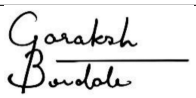
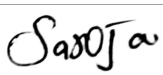
Name	Roll number	Contribution	Signature
Faayza Vora	23110109	Introduction, Safety measures, Materials and apparatus, Graphs, Observations and results for deionized and tap water compiling of the report.	
Hriday Pandya	23110136	Observations and results for both electrolytes, Performed electrolysis for the electrolytes,Compiling of the report.	
Goraksh Bendale	23110118	Performed the electrolysis for deionized and tap water	
Dishant Tanmay	23110100	Proceedure	
Haravath Saroja	23110127	Conclusion	

TABLE I: Author's Contribution