Experiment 6
Water Splitting Experiment

Jaskirat Singh Maskeen (23110146), Nishchay Bhutoria (23110222), Aayush Bundel (23110005),
Kavya Lavti (23110164), Kanhaiyalal (23110155)
Indian Institute of Technology
Gandhinagar

CONTENTS

I. INTRODUCTION

We aim to study the electrolysis of water, a fundamental process with various applications. This experiment involves converting electrical energy to chemical energy and hence, decomposing water and separating hydrogen and oxygen gases. This process is environment friendly, and the energy produced can be harnessed to form a $H_2 - O_2$ fuel cell.
During electrolysis, electrolyte molecules undergo oxidation at the anode, reduction at the cathode, or, in the case of water, oxygen at the anode and hydrogen at the cathode. We also used electrolytes such as $MgCl_2$ and $NaCl$ and compared the volume of hydrogen produced.

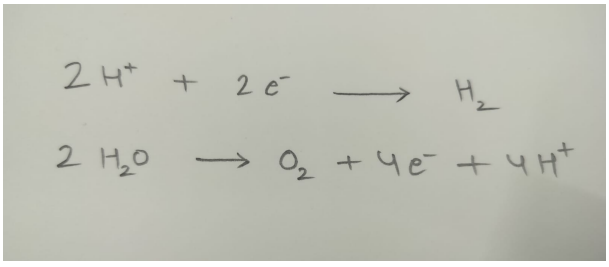


Fig. 1: oxidation and reduction of water

Safety Precautions:

i Make sure that the burettes with electrodes are filled with water.
ii Handle all apparatus with care.
iii Wear gloves, eyeglasses, and toe-covered shoes before entering the lab.
iv The burettes should not touch the base of the container, and the electrodes should be well inside the burette. They should not be partially inserted.

II. EXPERIMENT DETAILS

A. Apparatus

1) Beaker
2) 9 Volt Battery
3) Graduated Burettes

B. Materials

1) Deionized Water
2) Tap Water
3) Electrodes of Graphite
4) $NaCl$ solution
5) $MgCl_2$ solution.

C. Procedure

i We will be performing electrolysis for four different solutions:
   a) Deionized Water
   b) Tap Water
   c) DI water + $NaCl$
   d) DI water + $MgCl_2$
ii Connect the wires from the electrodes to the battery.
iii Put the electrodes in a tube filled with DI water (or deionized water), which is upside down in a container.
iv Connect the battery to start the electrolysis process. This makes hydrogen gas come out of one electrode (at the cathode) and oxygen gas out of the other (at the anode).
v The chemical reaction is that water splits into hydrogen and oxygen gases.
vi We expect hydrogen to collect in one burette and oxygen in the other.
vii Repeat the same procedure for tap water, $NaCl$ solution, $MgCl_2$ solution.

Preparation of $NaCl$ and $MgCl_2$ solution:

i Prepare 1 M solution of both $MgCl_2$ and $NaCl$.
ii Now, mix 15-20 ml solution of $NaCl$ and $MgCl_2$ in 150 ml of DI water to make the electrolyte solution.

III. Results

1) Deionized Water:
   We observe no bubbles on either the anode or cathode. This is due to the absence of ions to conduct electricity and oxidize or reduce the H^+ or OH^-.
2) Tap Water:
   We observe very slight bubbling near the wires connected to the electrodes, indicating a low but enough amount of ions in the water to conduct electricity and produce H_2 and O_2.
3) $NaCl$ + Deionized Water:
   With $NaCl$ mixed with deionized water, we observe bubbles forming at the anode and the cathode. Still, the volume of hydrogen produced was much more than the volume of oxygen produced at the anode.
4) $MgCl_2$ + Deionized Water:
   With $MgCl_2$ mixed with deionized water, we observe rapid bubbling and a significant volume of H_2 formed. The solution turned light yellow as well. This is because of the presence of chlorine, which dissolves in the water.

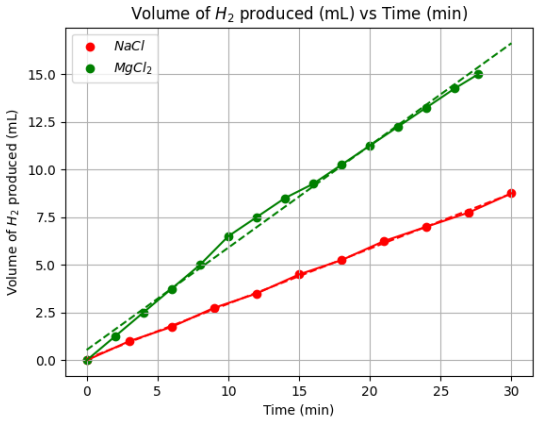


Fig. 2: Volume of H_2 vs. Time (min)

We do not measure the volume O_2 to observe electrolysis because:

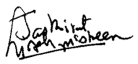
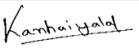
1) Oxygen formed is not pure as it can also oxidize from O^{2-} to O_2^{2-} (peroxide). So, at anode oxidation to both O_2 and O_2^{2-} will occur.
2) Due to presence of Cl^- ions, a Cl_2 might also form on the anode.
3) From stoichiometry, O_2 produced will be half of H_2 produced, so measuring the volume of hydrogen is much easier.
4) Oxygen dissolves more easily in water than hydrogen, so we won't obtain the actual 2:1 volume ratio, which we expect from stoichiometry.

From our above observations, $MgCl_2$ yields superior results than $NaCl$. This is due to the presence of more ions that lead to higher ionic conductivity, greater charge density of Mg^{2+} ions, and lower overpotential.

IV. Conclusion

In this experiment, we performed electrolysis of water with four different electrolytes. From observations of electrolysis of deionized water and tap water, we conclude that ions are necessary for facilitating electrolysis. When we added electrolytes like $NaCl$ and $MgCl_2$, the production of H_2 increased and was higher in the case of $MgCl_2$, which shows that the number of ions and higher charge density affect the ionic conductivity, hence affect the volume of H_2 produced. Ideally, after a long period, the graph should have flattened to show saturation of volume of H_2 produced because of reaching equilibrium. This electrolysis process is an efficient way to produce hydrogen, which can be used to power fuel cells.

V. Author Contribution

Name	Contribution	Signature
Jaskirat Singh Maskeen (23110146)	Document structure, Introduction, Results, Calculations and Conclusion.	
Nishchay Bhutoria (23110222)	Absent.	
Aayush Bundel (23110005)	Experimental details.	
Kavya Lavti (23110164)	Experimental details.	
Kanhiyalal (23110155)	Equations.	

Everyone present, contributed equally in the lab.