BS 192: Chemistry Lab Report Experiment 3: Water Splitting Experiment

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This experiment investigates the process of water electrolysis to generate hydrogen and oxygen gases. Electrolysis, a method that uses an electric current to drive a non-spontaneous reaction, was applied to deionized water, tap water, and electrolyte solutions (NaCl). The setup included graphite rod electrodes connected to a power source and submerged in water-filled inverted burettes. The rate of the reaction was observed by measuring the evolution of hydrogen gas over time. Results indicate that pure water exhibits minimal gas evolution, while the 0.2M NaCl solution showed a significant increase in hydrogen production, and an even larger increase was observed when we used 0.5M NaCl.

Index Terms - Electrolysis, Hydrogen Production, Electrodes, Electrolytes, Water Splitting.

I. Introduction

This experiment is about the electrolysis of water, which has various applications. It involves decomposition of water by separating hydrogen and oxygen gases with the help of electricity, hence, converting electricity into chemical energy. It is an environment friendly process and the energy produced can be utilized to form a H_2 - O_2 fuel cell.

However, deionized and tap water exhibit low electrical conductivity, making the electrolysis process inefficient. To improve the efficiency of electrolysis, electrolytes are added to water. Electrolytes are typically ionic compounds and hence dissociate in water to form ions, increasing the solution's conductivity and helping the electricity flow through the solution.

During electrolysis, the oxidation of electrolyte molecules occurs at anode and the reduction occurs at the cathode, so, in the case of water, oxygen at the anode and hydrogen at the cathode. The oxidation and reduction equations of water are as follows:

Half-cell reaction at the anode:

$$2\,H_2O \longrightarrow O_2 + 4\,H^+ + 4\,e^- \qquad (1)$$

Half-cell reaction at the cathode:

$$2\,H^+ + 2\,e^- \longrightarrow H_2 \qquad (2)$$

The overall reaction is:

$$2\,H_2O \longrightarrow 2\,H_2 + O_2 \qquad (3)$$

The efficiency of electrolysis of water is influenced by several factors such as the nature and concentration of the electrolyte present, types of electrodes used, the DC voltage applied and temperature etc. In this experiment we focused on observing the effect of NaCl salt on electrolysis with different concentrations. By testing different concentrations of NaCl, with deionized water and tap water, we aim to analyze the relationship between electrolyte concentration and the efficiency of the electrolysis process.

A. Safety Precautions:

- Handle all apparatus carefully.
- Wear gloves, safety glasses, and shoes.
- Make sure that the burettes with electrodes are filled with water.
- The electrodes should be well inside the burette, they should not be partially inserted, and the burettes should touch the base of the container.

II. Materials and Methods

A. Materials Required

1) Safety Glasses
2) Gloves
3) Beaker
4) Graduated Burettes
5) Foam Holder for Burettes
6) Battery (9V)
7) De-ionized Water
8) Tap Water
9) Copper Wires
10) Graphite Electrodes
11) NaCl Salt

B. Methods

1) **Preparation of NaCl solutions:**
   a) Weigh 1.1688g NaCl on a weighing balance and dissolve it in 100mL deionized water to make 100mL of 0.2 NaCl solution. (refer Fig. 2 for calculations)
   b) Weigh 2.922g NaCl on a weighing balance and dissolve it in 100mL deionized water to make 100mL of 0.5 NaCl solution. (refer Fig. 2 for calculations)
2) **Experimental Procedure:**

a) Place the electrodes in a deionized water-filled inverted burette in a beaker.
b) Connect the electrodes to the battery (9V PP3).
c) The chemical reaction is:

$$2\,H_2O \longrightarrow 2\,H_2 + O_2$$

Hydrogen gas evolves at cathode (negative electrode) and oxygen gas evolves at anode (positive electrode)
d) Bubbles will start to evolve at both the electrodes and collect at the top of the inverted measuring cylinders.
e) Repeat the steps (a) - (d) with tap water.
f) Repeat the steps (a) - (d) with 100 ml of 0.2 M NaCl solution.
g) The water level will go down as the hydrogen gas evolves.
h) Start the stopwatch when the water level reaches zero marking on the burette.
i) Record the water level (volume of hydrogen gas evolving) after an interval of every 1 minute for 15 minutes.
j) Repeat the steps (a) - (d) with 100 ml of 0.5 M NaCl solution.
k) Again, the water level will go down as the hydrogen gas evolves.
l) Start the stopwatch when the water level reaches zero marking on the burette.
m) Record the water level (volume of hydrogen gas evolving) after every 30 seconds for 10 minutes.

III. Results

A. Experiment with Deionized Water:

We conducted the experiment using deionized water, and we observed minimal electrolysis within the 10-minute duration. This is due to the lack of carrier charges since the deionized water contains very few impurities.

B. Experiment with Tap Water:

In contrast with the deionized water, we conducted the experiment using tap water, and we observed that a small amount of hydrogen gas is produced. This was slightly higher in comparison to our observation in deionized water, as tap water contains some ionic impurities, which act as charge carriers.

C. Experiment with NaCl solution:

It was apparent that the reaction was much faster this time such that meaningful readings could be taken. We measured the amount of H_2 trapped in intervals of 1 minute for 0.2M NaCl solution and 0.5 minutes for 0.5M NaCl solution. The reason for measuring H_2 evolved and not O_2 is because H_2 formed is twice the amount of O_2 formed. Below are the readings that we acquired.

TABLE I: Readings for the rate of H2 formation

0.2M NaCl solution		**0.5M NaCl solution**	
Time (in mins)	Volume of H_2 (in mL)	Time (in mins)	Volume of H_2 (in mL)
0	0.0	0	0.0
1	0.2	0.5	0.4
2	0.6	1	0.8
3	1.0	1.5	1.0
4	1.2	2	1.4
5	1.6	2.5	1.8
6	2.0	3	2.0
7	2.2	3.5	2.4
8	2.6	4	2.8
9	3.0	4.5	3.0
10	3.2	5	3.4
11	3.6	5.5	3.8
12	4.0	6	4.0
13	4.4	6.5	4.4
14	4.6	7	4.8
15	5.0	7.5	5.0
-	-	8	5.2
-	-	8.5	5.6
-	-	9	6.0
-	-	9.5	6.2
-	-	10	6.6

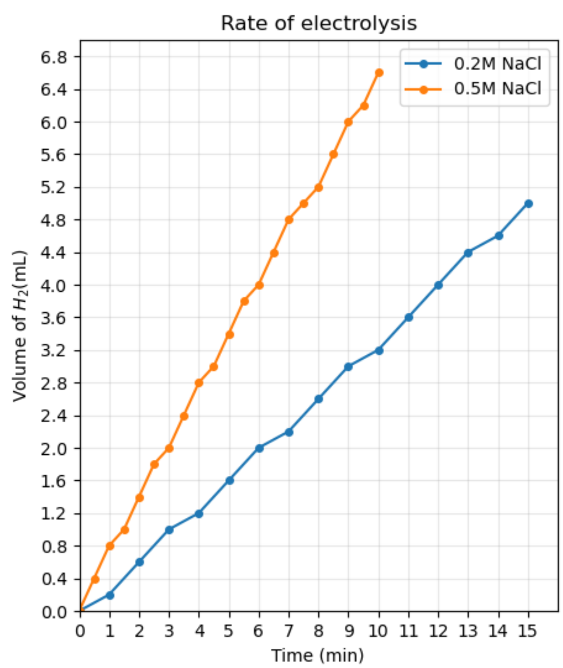


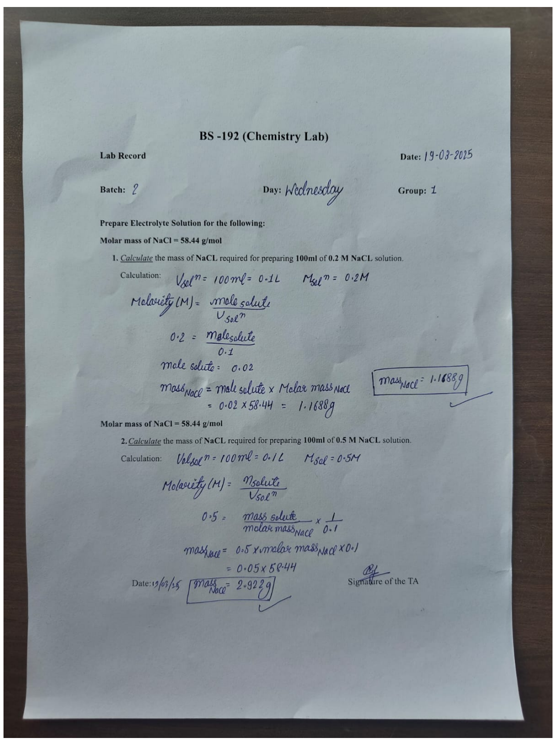
Fig. 1: Graph of volume of hydrogen gas evolved against time for 0.2M and 0.5M NaCl solutions

IV. Conclusion

The experiment demonstrated the difference between the electrolysis of the deionized water, tap water and the NaCl solutions with different molarities. Deionised water is a very poor conductor of electricity, resulting in a very slow electrolysis process with minimal hydrogen gas bubble production as it does not contain negligible amount of electrolytes. In tap water, some ions (e.g., calcium, magnesium, and other salts) are dissolved which increase conductivity and lead to faster hydrogen gas bubble evolution as compared to the deionised water.

However, the most effective way to increase the process of water electrolysis to produce H_2 gas is to add electrolyte, such as NaCl which significantly increases the rate of electrolysis by increasing the solution's conductivity. According to the experiment, it is evident that the greater number of electrolytes in the solution results in faster and more effective electrolysis. The experiment demonstrates that electrolytes play an important role in enhancing the efficiency of water electrolysis.

V. Images of Readings



BS -192 (Chemistry Lab)

Lab Record **Date:** 19-03-2025

Batch: 2 **Day:** Wednesday **Group:** 1

Prepare Electrolyte Solution for the following:

Molar mass of NaCl = 58.44 g/mol

1. *Calculate* the mass of **NaCL** required for preparing **100ml** of **0.2 M NaCL** solution.

Calculation: $V_{sol^n} = 100ml = 0.1L$ $M_{sol^n} = 0.2M$

$\text{Molarity}(M) = \frac{\text{mole solute}}{V_{sol^n}}$

$0.2 = \frac{\text{mole solute}}{0.1}$

$\text{mole solute} = 0.02$

$\text{mass}_{NaCl} = \text{mole solute} \times \text{Molar mass}_{NaCl}$

$= 0.02 \times 58.44 = 1.1688g$

$\boxed{\text{mass}_{NaCl} = 1.1688g}$

Molar mass of NaCl = 58.44 g/mol

2. *Calculate* the mass of **NaCL** required for preparing **100ml** of **0.5 M NaCL** solution.

Calculation: $Vol_{sol^n} = 100ml = 0.1L$ $M_{sol} = 0.5M$

$\text{Molarity}(M) = \frac{n_{solute}}{V_{sol^n}}$

$0.5 = \frac{\text{mass solute}}{\text{molar mass}_{NaCl}} \times \frac{1}{0.1}$

$\text{mass}_{NaCl} = 0.5 \times \text{molar mass}_{NaCl} \times 0.1$

$= 0.05 \times 58.44$

Date: 19/03/25 $\boxed{\text{mass}_{NaCl} = 2.922g}$

Signature of the TA

Fig. 2: Calculation Sheet Signed by TA

Fig. 2 shows the calculations required: We calculated the mass of NaCl to be dissolved in 100mL of deionized water to make 0.2M and 0.5M NaCl solutions. We also calculated the volume of hydrogen gas evolved against time for 0.2M and 0.5M NaCl solutions.

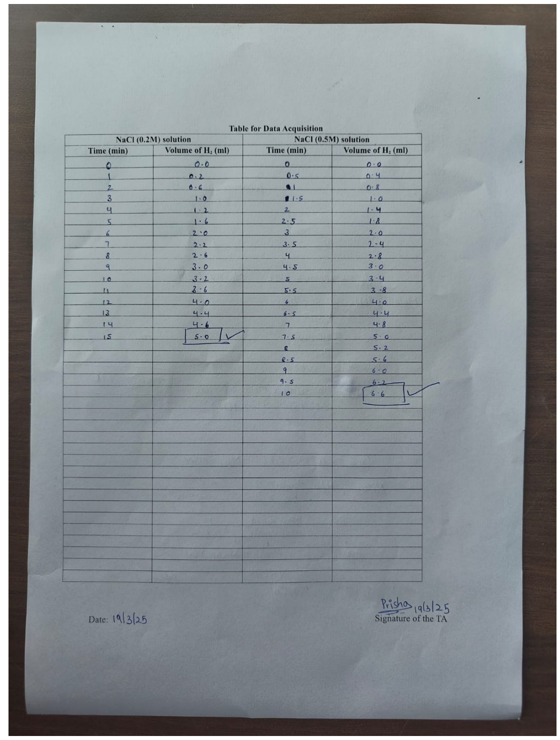


Table for Data Acquisition

NaCl (0.2M) solution		NaCl (0.5M) solution	
Time (min)	**Volume of H_2 (ml)**	**Time (min)**	**Volume of H_2 (ml)**
0	0.0	0	0.0
1	0.2	0.5	0.4
2	0.6	1	0.8
3	1.0	1.5	1.0
4	1.2	2	1.4
5	1.6	2.5	1.8
6	2.0	3	2.0
7	2.2	3.5	2.4
8	2.6	4	2.8
9	3.0	4.5	3.0
10	3.2	5	3.4
11	3.6	5.5	3.8
12	4.0	6	4.0
13	4.4	6.5	4.4
14	4.6	7	4.8
15	$\boxed{5.0}$	7.5	5.0
		8	5.2
		8.5	5.6
		9	6.0
		9.5	6.2
		10	$\boxed{6.6}$

Date: 19/3/25

Prisha 19/3/25
Signature of the TA

Fig. 3: Observation Sheet Signed by TA

Fig. 3 shows the readings taken during the experiment.

VI. Author Contributions

1) Akshit Chhabra, 24110026
   - Performed the experiment and recorded the readings on all the papers for fingerprint detection.
   - Completed the 'Abstract' and 'Author Contributions' sections and compiled, formatted the report on LaTeX.
2) Rayan Talukder, 24110294
   - Performed the experiment and performed the calculations for the NaCl solutions required to be prepared.
   - Completed the 'Results' section.
3) Rhythem Soni, 24110296
   - Performed the experiment and assisted in setting up the apparatus for the experiment.
   - Completed the 'Introduction' section and assisted in the 'Materials and Methods' section.
4) Rishi Soni, 24110297
   - Performed the experiment and prepared the NaCl solutions.
   - Completed the 'Conclusion' section.
5) Roshia Shweta, 24110304
   - Performed the experiment and assisted in setting up the apparatus for the experiment.
   - Assisted in the 'Materials and Methods' section.

References

[1] BS 192 Chemistry Lab Manual