

Lab report

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RATE OF REACTION – ELLIE MARTIN



Ewa Kazimierska

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1 Introduction

The concept of rate of reaction is fundamental in understanding how quick a chemical reaction occurs turning reactants into products. The change in concentration of reactants or the products are measured over time. Understanding the rate of reaction is fundamental within OME to correctly classify propellants based of the rate of detonation and deflagration [1]. In this report the rate of reaction between hydrochloric acid (HCL) and magnesium (Mg) and the volume of hydrogen gas which is produced is affected when the concentration of HCL, Temperature and the surface area of Mg is changed.

The controlled variables that can be changed to affect the rate of reaction: temperature, surface area, pressure and the introduction of a catalyst to reduce the activation energy of the reaction [4]. The dependent variable is the rate of reaction, and the controlled variables will vary depending on what is being changed but can include, initial temperature, catalyst which is being used, the volume of the solution you mix general variables that can affect rate of reaction with the specific ones that are relevant to the process of H₂ gas generation from HCl and Mg

2 Results

2.1 Effect of HCL concentrations on the speed of H₂ gas evolution

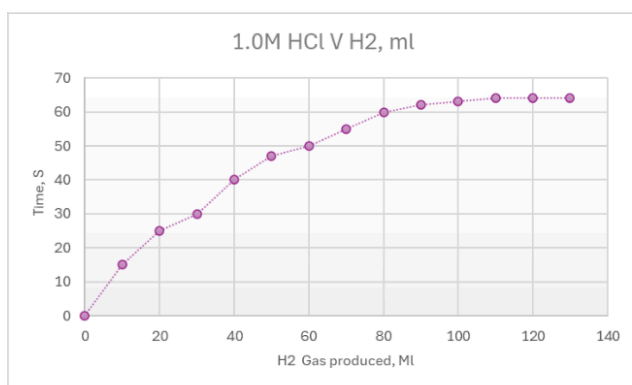
Table 1: ..

0.5M HCl							
Time, s	V H ₂ , ml	Time, s	V H ₂ , ml	Time, s	V H ₂ , ml	Time, s	V H ₂ , ml
0	0	220	26	440	42	660	45
10	1	230	27	450	42	670	45
20	1	240	28	460	43	680	45
30	2	250	29	470	43	690	45
40	4	260	30	480	43	700	45
50	6	270	30	490	44	710	45
60	7	280	31	500	44	720	45
70	8	290	32	510	44	730	45
80	11	300	33	520	44	740	45
90	13	310	33	530	44	750	46
100	14	320	33	540	44	760	46
110	14	330	34	550	44	770	46
120	15	340	34	560	44	780	46
130	16	350	35	570	45	790	46
140	17	360	36	580	45	800	46
150	18	370	37	590	45	810	46
160	20	380	38	600	45	820	46
170	20	390	38	610	45	830	46
180	22	400	39	620	45	840	46
190	24	410	41	630	45	850	46
200	24	420	41	640	45	860	46
210	26	430	41	650	45		

1.0M HCl	
Time, s	V H ₂ , ml
0	0
10	15
20	25
30	30
40	40
50	47
60	50
70	55
80	60
90	62
100	63
110	64
120	64
130	64

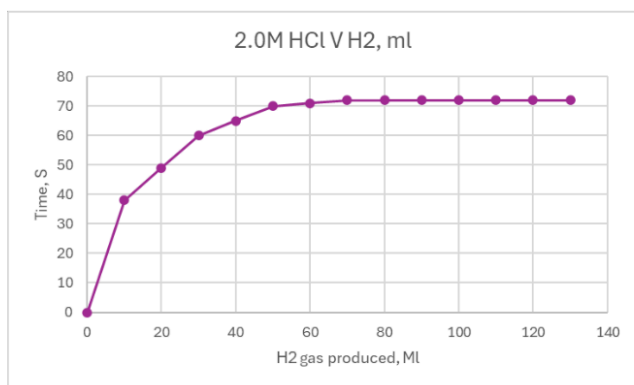
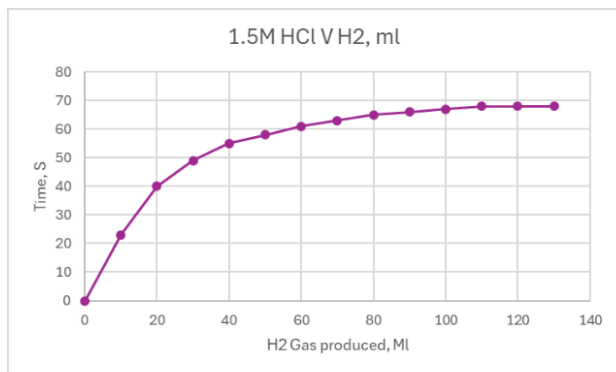
1.5M HCl	
Time, s	V H ₂ , ml
0	0
10	23
20	40
30	49
40	55
50	58
60	61
70	63
80	65
90	66
100	67
110	68
120	68

2.0M HCl	
Time, s	V H ₂ , ml
0	0
10	38
20	49
30	60
40	65
50	70
60	71
70	72
80	72
90	72



the axis are incorrectly titled

ACDB4011



plot for 0.5 M HCl is not shown; putting all plots in one graph would demonstrate the changes in rates more clearly

2.2 Effect of temperature on the speed of H₂ gas evolution

T ₁ = 46.6		T ₂ = 24.1	
Time, s	V H ₂ , ml	Time, s	V H ₂ , ml
0	7	0	0
10	14	10	15
20	17	20	25
30	19	30	30
40	23	40	40
50	25	50	47
60	31	60	50
70	35	70	55
80	38	80	60
90	41	90	62
100	41.5	100	63
110	42	110	64
120	42	120	64
130	42	130	64

T ₃ = 38.2	
Time, s	V H ₂ , ml
0	0
10	18
20	29
30	37
40	43
50	49
60	52
70	56
80	59
90	60
100	61
110	62
120	62
130	63
140	63
150	63
160	63
170	64

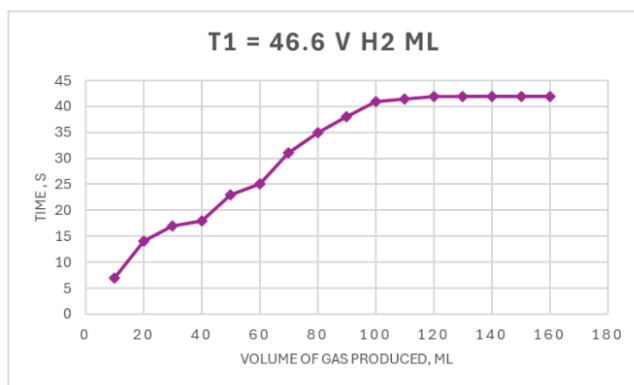
T ₄ = 48.1	
Time, s	V H ₂ , ml
0	0
10	20
20	30
30	37
40	42
50	47
60	51
70	53
80	54
90	54
100	44
110	55
120	55
130	56
140	57
150	57
160	58
170	59
180	60
190	61
200	62
210	62

ACDB4011

220	62
230	63
240	64
250	64

2.3 Effect of the surface area of Mg on the speed of H₂ gas evolution

T1 = 46.6	
Time S	V H ₂ ML
10	7
20	14
30	17
40	18
50	23
60	25
70	31
80	35
90	38
100	41
110	41.5
120	42
130	42
140	42
150	42
160	42



3 Discussion

In section 2.1 the effect of change in concentration on the rate of reaction displayed that as the concentration of the solution increases the rate of reaction also increases. This is due to the particles have more energy and they will have more successful collisions which will surpass the amount of activation energy which is required for a successful reaction this is known as collision theory.[4]

In section 2.2 this demonstrates the effect of increasing the temperature, however the results which were obtained do not fully support the hypothesis that as temperature increases so does the rate of reaction. The results show that the temperature does influence the rate of reaction however, after a certain temperature this is no longer a limiting factor as once all the particles are moving faster due to having more energy due to being heated-more successful collision occur over coming the activation energy [4]

In 2.3 the rate of reaction should have been increased due to the smaller surface area of the particles however this wasn't the case which could have been due to clumping in the material which meant the unequal distribution of masses through out the Mg reduces how fast the rate of reaction increased. This doesn't support the hypothesis which was introduced due to errors within the experiment..

In all of these experiments the gas syringe method was used as outlined in the methodology in appendix 1- this disadvantage of this method is that is common for gas leaks to occur within the system due to a poor seal or bung not being in place correctly which will affect the results obtained. To reduce this, it is important to ensure there are no leaks in the seals and when placing the bungs on the tests tubes this is done efficiently and ensure tight seal is achieved.

It is important to understand the rate of reaction when selecting what explosives is required depending on the type of result which is required. If the intended mission requires a faster reaction with propagation wave faster than the speed of sound is needed a high explosive which detonates is required [1] such as TNT. This differs to the reaction which occurs with a low explosive such as nitrocellulose as this will cause deflagration which still propagates however this process is slower than the speed of sound [2]. A combination of the two types for explosive is often used in attempt to use less of high explosives which are hard to confine once ignited in comparison to low explosives. [3]

4 Conclusion

In this report the effect that temperature, surface area and concentration was investigated to determine if this would increase the rate of reaction. As hypothesised these factors did increase the rate of reaction as the particles had more energy resulting in more successful collisions. There were errors in our results which effected how accuracy of our data such as potential clumping in the Mg which would affect the rate of reaction negatively.

The rate of reaction is important within OME as it allows different explosives to be tested and qualified to best suit the mission objective with one of the factors being rate of reaction as well as the amount of energy or yield which can be produced when formulated with other substances. Another important aspect of this technique is understanding the limiting factors of an explosive and if when subjected to increased atmospheric temperatures if this is likely to cause early detonation or deflagration.

5 Appendix 1- Methodology

Chemical used:

- Magnesium ribbon 4cm in length and weighed
- Magnesium powder- same mass as ribbon
- Hydrochloric acid (HCL) 2.0M
- Deionised water

Apparatus used

- Pipette
- Test tubes x4
- Test tube with arm?
- Large beaker
- Bunsen burner

Procedure Effect of HCL on the speed of H₂ gas evolution

- Four solutions of HCL were prepared with the concentrations :2.0M (stock), 1.5M, 1.0M and 0.5M. Done by using 2.0M HCL solution and deionised water.
- HCL with lowest concentration poured into test tube with arm.
- 4cm strip of Mg Ribbon was added to the test tube and bung quickly put in place. Stopwatch started.
- Volume of hydrogen given off was recorded in 10 second intervals until no more gas was being given off.
- Once reaction is completed the reaction mixture is discarded into waste beaker.
- This methodology was then followed for the three other concentrations.

Procedure -Effect of temperature on the speed of H₂ gas evolution

- Set up water bath and heat up beaker of water until temperature of water has increased by approx. 10.C for initial temperature.
- Pipette 20ml of 1.0M stock solution into three test tubes, wait until temperature of acid is the same as water bath.
- Transfer warm HCL into tube with arm and put 4cm of Mg ribbon inside and place the bung on top of test tube and start stopwatch.
- Time the reaction until no more gas is produced.

- Repeat for 2 more temperatures 10 degrees apart.

6 Bibliography

[1]

J. Akhavan, *The chemistry of explosives*. Cambridge: Royal Soc. Of Chemistry, 2012. *pages ? Ed?*

[2]

B. O'Connor, "Explosions, Deflagrations, and Detonations," *Nfpa.org*, Mar. 27, 2023.
<https://www.nfpa.org/news-blogs-and-articles/blogs/2023/03/27/explosions-vs-deflagrations-vs-detonations> (accessed May 13, 2025).

[3]

E.-C. Koch, *High Explosives, Propellants, Pyrotechnics*. 2021. *Pages? Ed?*

[4]

A. Burrows and E. Al, *Chemistry3 : introducing inorganic, organic and physical chemistry*. Oxford: Oxford University Press, Cop, 2013. *page? Ed?*

*when you cite a book to support specific statement you must
give the page number where this support can be found*

FINAL GRADE

GENERAL COMMENTS

58/100

Engagement with Literature Skills 8/15

Four references are cited, including two that relate to OME and two that support theoretical interpretation. IEEE formatting is inconsistent, and page numbers and edition details are missing from book references.

Feedback: Literature is relevant and applied effectively in the discussion. Ensure full IEEE compliance and provide complete reference details (e.g., page numbers, editions) for all sources.

Knowledge and Understanding Skills 11/20

The aim is specific and clearly states the relationship between the three variables and the reaction studied. A good definition of rate of reaction is included. Variables are discussed, though not explicitly classified as independent, dependent, or control. Collision theory is applied to explain the effect of three factors on rate. There is no formal hypothesis section, and the balanced chemical equation is not shown.

Feedback: Good conceptual understanding and aim. Include a formal hypothesis section, categorise variables, and provide the balanced chemical equation to ensure completeness and clarity.

Cognitive and Intellectual Skills 12/25

The discussion shows thoughtful interpretation, including the effect of concentration and temperature. Collision theory is applied in analysis however actual values of rate are not discussed. Experimental errors such as gas leaks and improper sealing are identified, and their effects considered. However, due to the absence of calculated rates, the analysis is purely qualitative. No rate laws, Arrhenius relationships, or numerical trends are explored, and graphical trends are incomplete, particularly for temperature and surface area.

Feedback: You interpret the experiment thoughtfully and recognise key experimental limitations. To strengthen your conclusions, calculate rates and connect them to theoretical models like rate laws or activation energy profiles.

Practical Application Skills 10/25

The data is clearly shown in tables, but most tables are not titled, and axes in graphs are occasionally incorrect. No graphs are included for the temperature or surface area investigations, which severely limits visual trend analysis. No reaction rates are calculated — neither average nor initial — despite this being the central aim of the experiment. Mole calculations are also missing, and though methods are described, their execution is not followed through in the results.

Feedback: The omission of calculated rates is a major flaw that undermines the practical objective. Include graphs for all conditions, calculate initial and average rates, and perform mole calculations to fully demonstrate quantitative laboratory skills.

Transferable/Professional Skills 9/15

The report is clearly structured with logical headings and professional tone. Passive voice is generally used. Tables and figures are properly referred to, but inconsistent formatting and missing titles reduce clarity. Some language is imprecise, affecting flow and readability. **Feedback:** Clear and professional structure. Ensure all tables are titled and all figures fully labelled to improve clarity and presentation.

PAGE 1

PAGE 2

PAGE 3

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PAGE 4

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PAGE 5

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Comment 3

how can you say this, if no calculations were performed?



Comment 4

this is more the case when temperature increases



Comment 5

which results?

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