

Rate of Reaction Lab Report

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Lab Report 4 – Rate of Reaction Experiments

Chemistry ACDB4011

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to make this purpose more relevant you could have introduced the actual

Section 1: Introduction

1.1 The purpose

The purpose of these experiments was to explore different factors which affect rate of reaction, including concentration, temperature and surface area. Rate of reaction is the speed at which a chemical reaction proceeds [1].

the 'what' is excellent! but 'why' is missing

1.2 The Hypothesis

1.2.1 Experiment 1

The aim of this experiment was to show that different concentrations of hydrochloric acid (HCl) would have different rate of reaction when mixed with a ribbon of magnesium. The null hypothesis (H_0) for this experiment is that there would be no change in rate of reactions with different concentrations of HCl. H_1 is that with an increase in concentration the rate of reaction would also increase.

1.2.2 Experiment 2

The aim of this experiment was to show that different temperatures influence the rate of reaction. The null hypothesis (H_0) for this experiment is that there would be no change in the rate of reaction with different temperatures. H_1 is that with the increase of temperature the rate of reaction will also increase.

1.2.3 Experiment 3

The aim of this experiment was to show that different surface areas of a reactant would influence the rate of reaction. The null hypothesis (H_0) for this experiment is that there would be no change to the rate of reaction with surface areas. The H_1 is that with the increase of surface area there would be an increase in rate of reaction.

1.3 Variables

1.3.1 Experiment 1

The control variables were the ambient temperature, surface area of the magnesium ribbon and the gas syringe. The independent variable was the concentration of the HCl. The dependent variable was the rate of reaction.

1.3.2 Experiment 2

The control variables were the concentration of the HCl, the gas syringe and the magnesium ribbon surface area. The independent variable was the temperature of the HCl. The dependent variable was the rate of reaction.

1.3.3 Experiment 3

The control variables were the concentration of HCl and the gas syringe. The independent variable was the surface area of the magnesium ribbon. The dependent variable was the rate of reaction.

Section 2: Results

2.1 Experiment 1

In this experiment 4 different concentrations of HCl were individually combined with a magnesium ribbon to whether different concentrations of a reactant have an effect of rate of reaction. The results are shown below:

Table 1 – Result from Experiment 1

0.5 mol		1 mol		1.5 mol		2.0 mol	
Time (seconds)	Volume of H ₂ (mL)	Time (seconds)	Volume of H ₂ (mL)	Time (seconds)	Volume of H ₂ (mL)	Time (seconds)	Volume of H ₂ (mL)
0	0.0	0	0.0	0	0.0	0	0.0
20	1.0	10	4.0	10	17.0	10	33.0
40	3.0	20	8.0	20	28.0	20	49.0
60	5.0	30	11.5	30	36.0	30	56.0
80	7.0	40	14.5	40	43.0	40	62.0
100	8.5	50	17.5	50	48.0	50	66.0
120	10.0	60	20.5	60	51.0	60	70.0
140	12.0	70	23.5	70	52.0	70	72.0
160	14.0	80	26.5	80	52.5	80	72.0
180	16.0	90	29.5	90	52.5	90	72.0
200	17.0	100	32.5	100	53.0	100	72.0
220	18.5	110	35.0	110	53.0	110	72.0
240	20.0	120	37.5	120	53.0	120	72.0
260	21.0	130	39.5	130	53.0	130	72.0
280	22.5	140	42.0	140	53.0	140	72.0
300	24.0	150	44.0	150	53.0	150	72.0
320	25.0	160	46.0	160	53.0	160	72.0
380	29.0	170	48.0	-	-	-	-
400	29.5	180	49.5	-	-	-	-
420	30.0	190	51.5	-	-	-	-
440	31.0	200	53.0	-	-	-	-
460	32.0	210	54.5	-	-	-	-
480	33.0	220	55.5	-	-	-	-
500	33.5	230	56.5	-	-	-	-
520	34.0	240	57.5	-	-	-	-
540	35.0	250	57.5	-	-	-	-
560	36.0	260	58.0	-	-	-	-
580	36.5	270	58.0	-	-	-	-
600	37.0	280	58.0	-	-	-	-
620	37.5	290	58.0	-	-	-	-
640	38.0	300	58.0	-	-	-	-
660	38.5	-	-	-	-	-	-
680	39.0	-	-	-	-	-	-
700	39.5	-	-	-	-	-	-
720	40.5	-	-	-	-	-	-
740	41.0	-	-	-	-	-	-
760	41.0	-	-	-	-	-	-

780	41.5	-	-	-	-	-	-
800	42.0	-	-	-	-	-	-
820	42.0	-	-	-	-	-	-
840	42.0	-	-	-	-	-	-
860	42.0	-	-	-	-	-	-
880	42.0	-	-	-	-	-	-
900	42.5	-	-	-	-	-	-
920	42.5	-	-	-	-	-	-
940	42.5	-	-	-	-	-	-
960	42.5	-	-	-	-	-	-
980	42.5	-	-	-	-	-	-
1000	42.5	-	-	-	-	-	-

how did you
determine this?

Table 2 – Rate of reaction Results from Experiment 1

HCl Concentration (molarity)	Time taken to Dissolve Mg (seconds)	Average Rate (mL/s)	Instantaneous rate at t=0 (mL/s)
0.5	900	0.0472	0.050
1.0	260	0.223	0.40
1.5	100	0.530	1.7
2.0	70	1.03	3.3

graph
you can remove the 1.03 from the graph if you give the same or similar name to the figure

The average rate of the reaction was calculated by dividing the volume of H₂ created by the reaction by the time taken for the reaction to be complete.

The below shows how the different rates of reaction compare with each other:

putting these four plots in one figure clearly shows the trend; well done

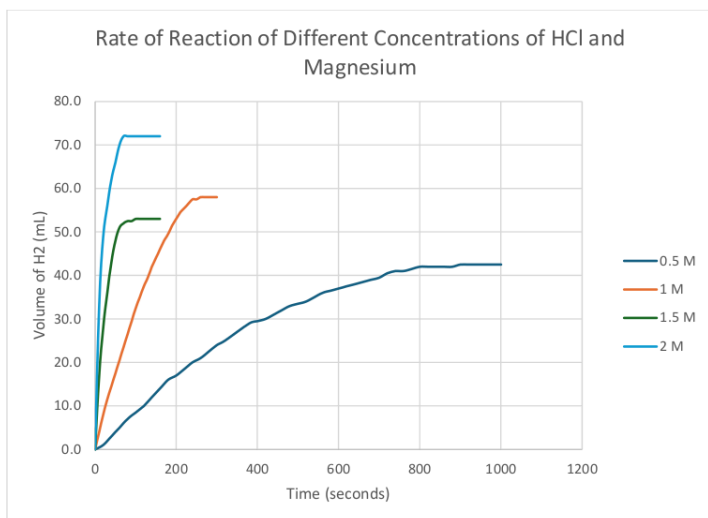


Figure 1 – Comparison of Rates of Reactions for Experiment 1

2.2 Experiment 2

In this experiment the effect of temperature on rate of reaction was being tested. Three different temperatures of HCl were tested where a magnesium ribbon was placed in all of them and the speed of H_2 evolution was recorded. The below shows the results:

Table 3 – Results from Experiment 2

Time	24.6°C	41.1°C	50.1°C
	Volume of H_2 (mL)	Volume of H_2 (mL)	Volume of H_2 (mL)
0	0.0	0.0	0.0
10	4.0	22.0	22.0
20	8.0	30.0	34.0
30	11.5	41.0	43.0
40	14.5	46.0	50.0
50	17.5	53.0	55.0
60	20.5	57.0	60.0
70	23.5	59.0	63.0
80	26.5	60.0	64.0
90	29.5	60.5	64.0
100	32.5	60.5	64.0
110	35.0	60.5	64.0
120	37.5	60.5	64.0
130	39.5	-	-
140	42.0	-	-
150	44.0	-	-
160	46.0	-	-

170	48.0	-	-
180	49.5	-	-
190	51.5	-	-
200	53.0	-	-
210	54.5	-	-
220	55.5	-	-
230	56.5	-	-
240	57.5	-	-
250	57.5	-	-
260	58.0	-	-
270	58.0	-	-
280	58.0	-	-
290	58.0	-	-
300	58.0	-	-

These results were then used to calculate average rate of reaction by dividing the volume of H_2 by the time taken for the reaction to complete. These results can be seen below:

Table 4 – Rate of Reaction Results from Experiment 2

Temperature ($^{\circ}C$)	Time Taken to Dissolve Mg (seconds)	Average Rate (mL/s)	Instantaneous rate at $t=0$ (mL/s)
24.6	260	0.223	0.4
41.1	90	0.67	2.2
50.1	80	0.80	2.2

The below shows how the different rates of reactions compare with each other.

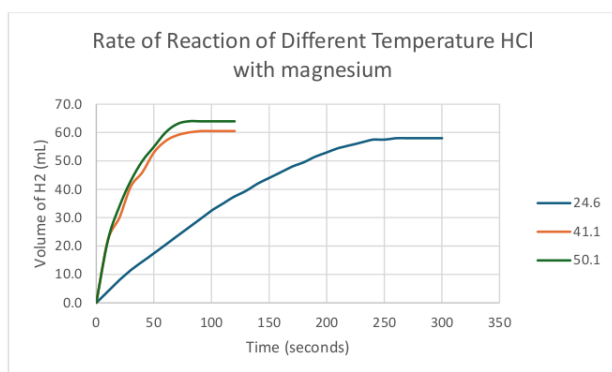


Figure 2 – Comparison of Rates of Reactions for Experiment 2

2.3 Experiment 3

In this experiment the effect of surface area on rate of reaction was being tested. Two different samples of magnesium were being tested with HCl, one was a ribbon of magnesium, and the other was turnings of magnesium. The volume of H₂ produced was recorded and shown below:

Time (seconds)	Magnesium Ribbon	Magnesium Turnings
	Volume of H ₂ (mL)	Volume of H ₂ (mL)
0	0.0	0.0
10	4.0	12.0
20	8.0	18.0
30	11.5	24.0
40	14.5	30.0
50	17.5	36.0
60	20.5	41.0
70	23.5	44.0
80	26.5	48.0
90	29.5	52.0
100	32.5	55.0
110	35.0	58.0
120	37.5	60.0
130	39.5	62.0
140	42.0	64.0
150	44.0	66.0
160	46.0	68.0
170	48.0	70.0
180	49.5	71.0
190	51.5	71.5
200	53.0	72.0
210	54.5	73.0
220	55.5	73.5
230	56.5	73.5
240	57.5	73.5
250	57.5	73.5
260	58.0	73.5
270	58.0	-
280	58.0	-
290	58.0	-
300	58.0	-

These results were then used to calculate the rates of reaction, these are shown in the table below:

	Mass (g)	Moles (mol)	Average Rate of Reaction (mL/s)	Instantaneous Rate of Reaction at t=0 (mL/s)
Magnesium turnings	7.65	0.315	0.334	1.2
Magnesium Ribbon	7.65	0.315	0.223	0.4

The below graph shows how the different rates of reaction compare with each other:

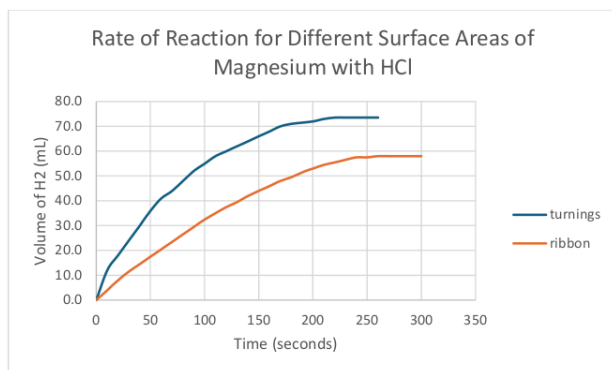


Figure 3 – Comparison of Rates of Reactions Experiment 3

Section 3: Discussion

3.1 General Overview

In experiment 1 there was enough evidence to reject the null hypothesis and accept H_1 . As with every time the concentration of HCl is increased the rate of reaction also increases.

In experiment 2 there was enough evidence to reject the null hypothesis and accept H_1 . As with every time the temperature of the HCl was increased the rate of reaction also increased.

In experiment 3 there was enough evidence to reject the null hypothesis and accept H_1 . As the rate of reaction of the magnesium turnings was higher than the rate of reaction of the magnesium ribbon

3.2 Relevance to OME

page missing; when you reference book page number where the referenced information can be found should be clearly stated

Primary and Secondary explosives have different activation energies required to start their reaction [2]. The activation energies magnitude determines the rate of reaction [2].

3.3 Limitations and errors

All of these experiments would be more accurate if they were repeated several times with the same concentrations, temperatures and surface areas. Then further testing should be done to include more concentrations, temperatures and surface areas to further proves the above hypothesis.

Section 4: Conclusions

4.1 Summary

All three null hypothesis were rejected and all three H_1 were accepted as the rate of reaction increased with increased, temperature, increased concentration and increased surface area.

4.2 Directions for Further Use

Knowing the rates of reactions for all explosives could be helpful in achieving more efficient explosives and knowing when high concentrations and temperatures would no longer increase the rate of reaction.

Section 5: References

[1] K. J. Laidler, "Rate Reaction, Encyclopedia Britannica" 20 August 2024, [Online]. Available: [Reaction mechanism | Definition, Examples, Chemistry, & Facts | Britannica](#)

[2] J. Akhavan, The Chemistry of Explosives, 4th Edition. Cambridge: RSC Publishing, 2022.

Section 6: Appendix

6.1 Materials and Method

6.1.1 Apparatus Needed for all Experiments

- Long test tube with arm
- Gas syringe
- Rubber bung and delivery tube to fit the test tube
- Two large beakers for the water bath and reaction mixture
- Pipette and pipette filler
- Two clamp stands
- Test tube holder
- Thermometer
- Ring stand, Bunsen burner, clay triangle
- Stopwatch

6.1.2 Experiment 1 Method

1. Prepare FOUR 20.0 mL solutions of HCl with the following concentrations: 2.0 M (stock), 1.5 M, 1.0 M and 0.5 M. Use the pipette to measure appropriate volumes of the 2.0 M HCl solution and DI water.
2. Pour the HCl solution with the lowest concentration into the test tube with arm.
3. When ready, add a 4 cm strip of magnesium ribbon to the test tube, quickly put the bung back, and start the stopwatch.
4. For 1 M HCl use the Mg ribbon from the premeasured vial. This set of data will be needed for Part 3.
5. Record the volume of hydrogen gas given off at suitable intervals (e.g. 10 seconds). Continue timing until no more gas is given off.
6. After the reaction is completed, discard the reaction mixture in the waste beaker.
7. Measure the temperature of 1.0 M HCl. It will be needed for Part 2.
8. Repeat the same experiment for three other concentrations of HCl.

6.1.3 Experiment 2 Method

1. Set up a water bath. Pour water into the large beaker and heat it over the Bunsen burner till the temperature of water increases by approximately 10 degC when compared to the initial temperature of 1 M HCl measured in the previous part.
2. Pipette 20 mL of 1.0 M stock solution into three test tubes.
3. Place the first test tube with 1.0 M HCl in the water bath and wait until the temperature of the acid reaches the temperature of the water in the water bath.
4. Quickly transfer the warm HCl into the tube with the arm, put 4 cm piece of magnesium ribbon, put the bung back, and start the stopwatch.
5. Continue timing until no more gas is given off.
6. After the reaction is completed, discard the reaction mixture in the waste beaker.
7. Repeat the same experiment for two more temperatures (ideally 10 degC apart).

6.1.4 Experiment 3 Method

1. Use the pipette to transfer 20 mL of 1 M HCl at room temperature into the test tube with arm.
2. Quickly add the Mg turnings into the test tube, put the bung back, and start the stopwatch.
3. Continue timing until no more gas is given off.
4. After the reaction is completed, discard the reaction mixture in the waste beaker.

6.2 Scan of Original Data Sheet

L. Effect of concentration of HCl on speed of H_2 gas evolution:

0.5 M HCl		1.0 M HCl		1.5 M HCl		2.0 M 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	0	0	0	0	0	0
20	1	10	4	10	17	10	33
40	3	20	8	20	33	20	49
60	5	30	11.5	30	36	30	56
80	7	40	14.5	40	43	40	62
100	8.5	50	17.5	50	48	50	65
120	10	60	20.5	60	51	60	70
140	12	70	23.5	70	52	70	72
160	14	80	26.5	80	52.5	80	72
180	16	90	29.5	90	52.5	90	72
200	17	100	32.5	100	53	100	72
220	18.5	110	35	110	53	110	72
240	20	120	37.5	120	53	120	72
260	21	130	39.5	130	53	130	72
280	22.5	140	42	140	53	140	72
300	24	150	44	150	53	150	72
320	25	160	46	160	53	160	72

[HCl]	time to dissolve Mg	average rate	instantaneous rate at $t = 0$ s
0.5 M	900s	0.0472	0.050
1.0 M	260s	0.223	0.40
1.5 M	100s	0.530	1.70
2.0 M	70s	1.03	3.30

* the rest of the data on a separate sheet.

II. Effect of temperature on speed of H_2 gas evolution

T2 = 41.1		T3 = 50.1		T4 = 61.1	
time, s	V H ₂ , mL	time, s	V H ₂ , mL	time, s	V H ₂ , mL
0	0	0	0	0	0
10	22	10	22		
20	30	20	34		
30	41	30	43		
40	46	40	50		
50	53	50	55		
60	57	60	60		
70	59	70	63		
80	60	80	64		
90	60.5	90	64		
100	60.5	100	64		
110	60.5	110	64		
120	60.5	120	64		

temperature	time to dissolve Mg	average rate	instantaneous rate at
			t = 0 s
T1	260s	0.223 ~~0.223~~	0.40
T2	90s	0.51 ~~0.51~~	2.2
T3	80s	0.80 ~~0.80~~	2.2
T4	—	—	—

Rate of Reaction Lab Report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

61 / 100

Engagement with Literature Skills 9/15

You cite two sources, one of which (Akhavan) is academically appropriate and relevant to OME. However, theoretical concepts such as collision theory and rate laws are not supported by literature, and one reference is non-academic (Britannica). IEEE formatting is inconsistent, and citation details (e.g., access dates, full titles) are incomplete.

To improve: Use academic literature to support theoretical explanations (e.g., activation energy, collision theory). Format all references according to IEEE standards, including edition, publisher, and access dates where applicable.

Knowledge and Understanding Skills 11/20

Your hypotheses are clearly stated and variables are accurately classified across all experiments. The aim is well defined, and there is a basic understanding of how each factor affects rate. However, the balanced chemical equation is missing, and there is no in-depth explanation of kinetic principles such as molecular collisions or activation energy.

To improve: Include the balanced chemical equation for $\text{Mg} + \text{HCl}$. Link your hypotheses to underlying scientific theories, such as the collision theory and the Arrhenius equation, to demonstrate a deeper conceptual understanding.

Cognitive and Intellectual Skills 14/25

You calculate and present both average and initial rates across all experiments, and you use this data to support your conclusions effectively. The comparative graphs are well-structured. However, there is limited theoretical interpretation of trends, and no rate laws or activation energy models are referenced. The discussion of OME relevance is brief and lacks technical depth.

To improve: Explain how your calculated rates relate to theoretical models (e.g., first-order kinetics). Expand the OME section by linking your findings to reaction kinetics in propellants or explosives more directly.

Practical Application Skills 16/25

Your data is well presented, and key calculations are completed. Graphs are used to compare outcomes, and mole values are calculated for surface area trials. Methods are clearly written and show good attention to experimental design. However, there is no mention of error sources (e.g., timing, gas syringe

issues), and data presentation could be improved with better labelling and units.

To improve: Discuss sources of error and how they may have influenced your results. Ensure all figures and tables are clearly titled, labelled, and include appropriate units.

Transferable/Professional Skills 11/15

The report is clearly structured with a logical flow and formal tone. Section headings are used effectively, and the overall organisation is good. Some minor issues with language and formatting remain, and referencing needs to be refined.

To improve: Proofread for clarity and consistency. Use precise scientific language and ensure visual elements (tables, figures) are formatted professionally.

PAGE 1

PAGE 2

PAGE 3

Text Comment. to make this purpose more relevant you could have introduced the actual chemical process and write the chemical equation

PAGE 4

Text Comment. the 'what' is excellent! but 'why' is missing

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PAGE 5

PAGE 6

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Text Comment. graph

Text Comment. you can remove the title from the graph if you give the same or similar name to the figure

Text Comment. putting these four plots in one figure clearly shows the trend; well done

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PAGE 7

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PAGE 9

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