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Chemistry 12

Lab 1B: Factors Affecting Reaction Rate

1 Purpose

To investigate the effect concentration, temperature, and surface area have on the rate of reaction in the following two reactions:

$$\mathrm{CaCO_3(s) + 2\,HCl(aq) \longrightarrow CO_2(g) + CaCl_2(aq) + H_2O\,(l)}$$
$$\mathrm{C_6H_8O_7(aq) + 3\,NaHCO_3(s) \longrightarrow 3\,H_2O\,(l) + 3\,CO_2(g) + Na_3C_6H_5O_7(aq)}$$

The first reaction will be between Calcium Carbonate and Hydrochloric Acid, varying the concetration of the acid. The second reaction will be between the Citric Acid and Sodium Bicarbonate in a denture tablet, varying the temperature and surface area.

2 Procedure

2.1 Concentration Test Procedure

1. Two similar $CaCO_3$ rocks were picked and weighed.
2. The weight of a beaker was measured and the scale zeroed.
3. 50.0mL of 1.0M HCl was poured into the beaker.
4. The weight of the HCl and a $CaCO_3$ rock combined was measured and recorded.
5. The $CaCO_3$ rock was dropped into the beaker.
6. Weight measurements of the system were taken every 30 seconds for 5 minutes.
7. The process was repeated with the other rock in 3.0M HCl.

2.2 Temperature and Surface Area Test Procedure

1. 50.0mL of room temperature water was poured into two beakers, and 50.0mL of boiling water into another beaker.
2. 3 denture tablets were picked and weighed.
3. A beaker with water was zeroed on the scale.
4. A denture tablet was dropped into the water and weight measurements were taken every 30 seconds for 5 minutes, stopping once fully dissolved.
5. This was done 3 times. A control test with room temperature water, a surface area test with a denture tablet crushed into a fine power, and a heated test with boiling water, and

3 Data/Observations

3.1 Concetration Test

3.1.1 Concentration Test Data

Table 1: Initial Parameters of Open $CaCO_3$(s) and HCl(aq) Reaction.

Parameter	**Test 1**	**Test 2**
Concentration HCl (M)	1.0	3.0
Mass HCl (g)	17.9	32.5
Mass CaCO3 (g)	10.6	13.7
Mass Total (g)	28.5	46.2

Table 2: Change in Mass Over Time of an Open $CaCO_3$(s) and HCl(aq) Reaction.

Time	**Test 1 Mass (g)**	**Test 2 Mass (g)**
0:00	28.5	46.1
0:30	28.3	46.0
1:00	28.3	45.8
1:30	28.2	45.6
2:00	28.1	45.4
2:30	28.0	45.3
3:00	28.0	45.1
3:30	27.9	45.0
4:00	27.9	44.9
4:30	27.9	44.9
5:00	27.8	44.8

The mass data collected in Table 2 is the sum of the mass of the HCl(aq) solution and the $CaCO_3$(s) rock.

3.1.2 Concentration Test Observations

The two samples of $CaCO_3$(s) were similar in shape and size. Both HCl(aq) solutions were clear and colorless. In both tests, fizzing was observed during the reaction. However with the higher concentration acid, a much more vigorous fizzing was observed alongside a pungent smell and the solution becoming darker. The tests were not carried to completion due to time constraints.

3.2 Temperature and Surface Area Test Data

3.2.1 Our Group's Data

Table 3: Initial Parameters of Open Denture Tablet Reactions.

Parameter	**Test 1 (Control)**	**Test 2 (Crushed)**	**Test 3 (Heated)**
Crushed	no	yes	no
Heated	no	no	yes
Mass Beaker-Water (g)	98.0	75.6	80.9
Mass Tablet (g)	2.6	2.5	2.5

Table 4: Change in Mass Over Time of Open Denture Tablet Reactions.

Time	**Test 1 Mass (g)**	**Test 2 Mass (g)**	**Test 3 Mass (g)**
0:00	2.5	2.5	2.5
0:30	2.5	2.4	2.4
1:00	2.5	2.4	2.4
1:30	2.5	2.4	2.4
2:00	2.5	2.4	2.4
2:30	2.5	2.4	—
3:00	2.5	2.3	—
3:30	2.5	2.3	—
4:00	2.5	—	—
4:30	2.5	—	—
5:00	2.4	—	—

The mass data collected here is based on the mass of the denture tablet. The scale was zeroed with the beaker and water. Data was not collected after the tablet was fully dissolved.

3.2.2 Abigail & Jersey's Data (Video)

Table 5: Initial Parameters of Open Denture Tablet Reactions.

Parameter	**Test 1 (Control)**	**Test 2 (Crushed)**	**Test 3 (Heated)**
Crushed	no	yes	no
Heated	no	no	yes
Mass Tablet (g)	2.57	2.53	2.59

Table 6: Change in Mass Over Time of Open Denture Tablet Reactions.

Time	**Test 1 Mass (g)**	**Test 2 Mass (g)**	**Test 3 Mass (g)**
0:00	2.57	2.49	2.59
0:30	2.54	2.53	2.45
1:00	2.47	2.48	2.39
1:30	2.51	2.49	2.27
2:00	2.47	2.53	2.19
2:30	2.46	2.50	2.24
3:00	2.46	2.42	2.20

3.2.3 Temperature & Surface Area Test Observations

All three denture tablets were very similar in shape (initially), size, weight, and color. The crushed tablet was in a fine, even powder. The water appeared clear and odourless prior to the tests. During all three tests, foam formed on the surface of the water and the solution in the beaker turned a green colour. Halfway through the crushed tablet test, the solution turned a turqouise colour similar to seawater. During the heated water test, yellow splotches appeared on the surface of the foam. The crushed tablet and heated water tests were carried until the tablet was visibly dissolved. The control test was not carried to completion due to time constraints.

Minimal weight change was observed in our tests due to the precision of our scale (1 decimal place). However in Abigail and Jersey's tests (2 decimal places), fluctuating weight change was observed.

4 Analysis

4.1 Concentration Test Analysis

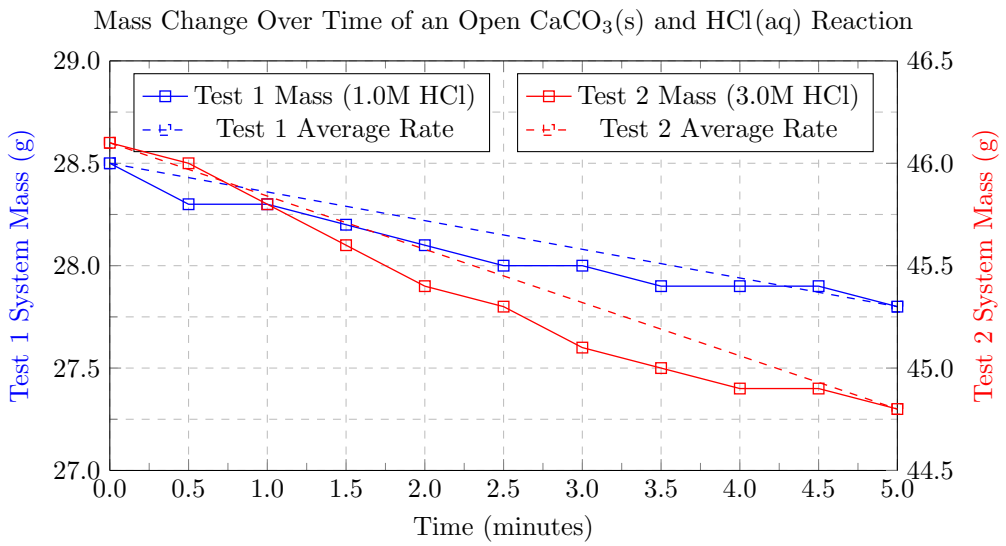

Figure 1: Change in mass of the system with average rates over the first 5 minutes of data.

For the reaction $CaCO_3(s) + 2\,HCl(aq) \longrightarrow CO_2(g) + CaCl_2(aq) + H_2O(l)$, the average rate in $\frac{g\,CO_2}{min}$ can be seen in the graph to have a higher magnitude for the 3.0M HCl test. This can be verified by calculating the average rate for both tests:

$$\text{Average Rate}_{1.0M} = \frac{28.5\,g - 27.8\,g}{5\,min} = 0.14\,\frac{g\,CO_2}{\text{min}}$$
$$\text{Average Rate}_{3.0M} = \frac{46.1\,g - 44.8\,g}{5\,min} = 0.26\,\frac{g\,CO_2}{\text{min}}$$

4.2 Temperature & Surface Area Test Analysis

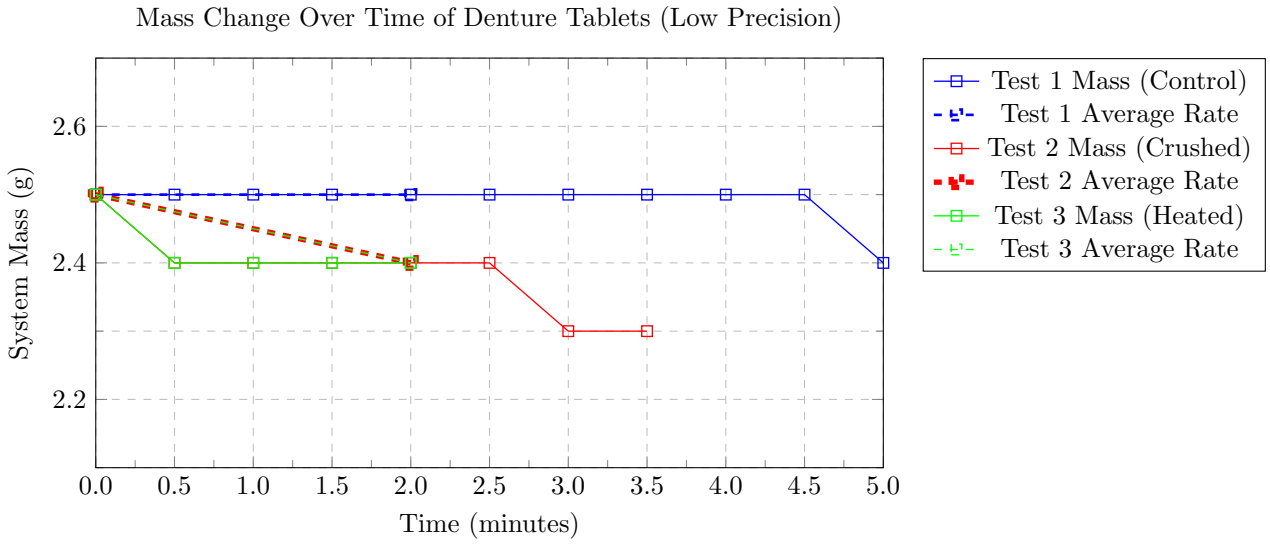

Figure 2: Change in mass of the system with average rates over the first 2 minutes of data.

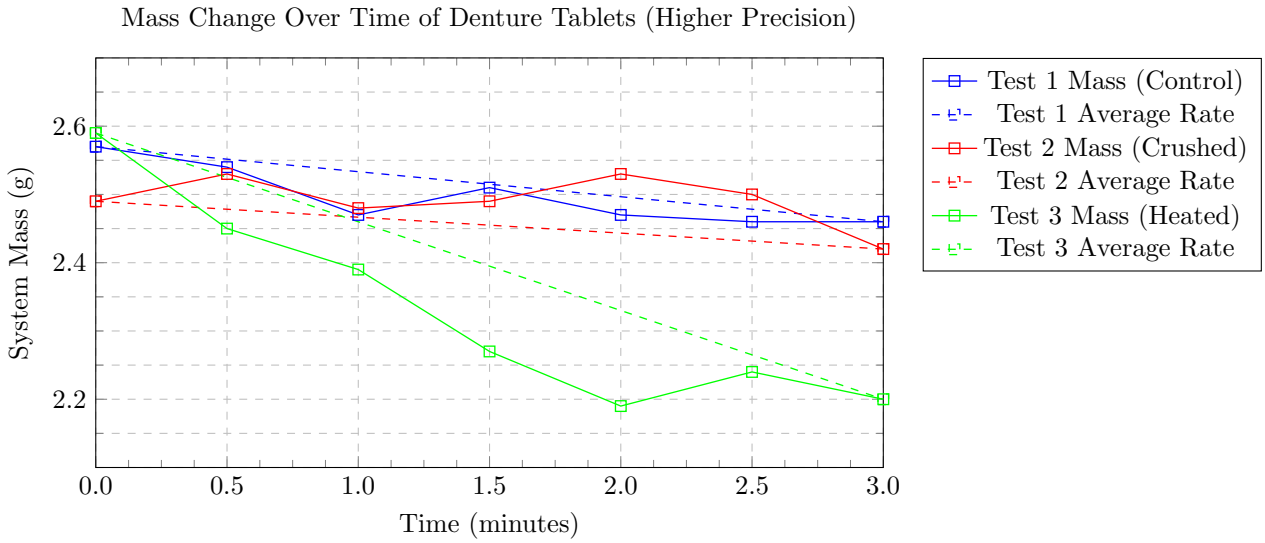

Figure 3: Change in mass of the system with average rates for temperature and surface area test over the first 3 minutes of data with 2 decimal places of precision. (Abigail & Jersey's data.)

5 Conclusion