

Pritesh Mistry 10H  
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## **Chemistry Coursework: Investigating the effect of Concentration on the Rate of Reaction**

In the investigation that I am going to do I am going to try and find out how the rate of reaction is affected by different concentrations of acid, ranging from 1M to 2.5M.

### **Variables**

The variables in this experiment will be the concentration of the acid. The surface area of the marble chips could also be a variable, but not to such an extent because this is only variable as there is no accurate way in measuring the surface area of the marble chips. In this case the key variable being the concentration of the acid. The elements that will be kept constant will be temperature (kept at room temperature), the size and weight of the marble chips, the volume of acid, and the time intervals at which the results will be recorded (10 secs).

### **Prediction**

I predict that if you increase the concentration of the acid then it will increase the rate of reaction. The reason for this is that in a more concentrated acid there are more acid particles, which means more successful collisions, which results in a faster reaction. For example a 2M acid will go twice as fast as a 1M acid because there are twice as many acid particles. If there are twice as many acid particles, this means that there will be twice as many collisions, therefore doubling the pace of the reaction meaning the reaction is more reliable. I also predict that the size and surface area of the marble chips will also have an effect on the rate of reaction, because in theory the smaller the marble chips the larger the surface area, which gives a faster reaction. My main prediction is that the 2.5M acid will react the quickest, then the 2M acid, then the 1.5M acid, and finally the 1M acid.

### **Plan**

#### **Labelled Diagram**

## **Apparatus**

- Bowl (filled with water)
- 2 Measuring Cylinders
- Stopwatch
- Boiling tube (with a rubber tube attached to it) & Bung
- Test tube Rack
- 30cm<sup>3</sup> Hydrochloric Acid (1M, 1.5M, 2M, 2.5M)
- Medium sized marble chips (weighing 2.4g – 2.6g)

## **Method**

Firstly all the apparatus will be set up according to how the investigation will be carried out. Next we got groups of 5 medium sized marble chips and weighed them, as we had chosen to have the weight of them at 2.4g – 2.6g, we tried to find the same sized amounts of chips at the same weight. After that we poured 30cm<sup>3</sup> of 1M acid into the boiling tube, and put the rubber tube of the boiling tube into the bowl of water, and put it into the measuring cylinder, which was full of water. After that, we put the marble chips into the boiling tube of acid, covered it with a bung, and started the stopwatch. After this every ten seconds we took a record of how much gas had been produced, this was done by looking at how much water had been bubbled away from the measuring cylinder. We carried on taking results every ten seconds for the next three minutes or until all the acid had been reacted. When all this had been done, we repeated the above, another 2 times making it three times in total, so that we could take an average of the three, to give a reliable result. When this had been done with the 1M acid, we moved onto the 1.5M acid and did everything above three times, then did the same for the 2M acid, and then for the 2.5M acid.

The investigation was made fair by using all the same apparatus for all the acids, and using the same time intervals, as well as the same marble chips, and acid. There wasn't really a great deal needed to make the investigation safe, except that quite a strong acid was used, but when it was used it was used safely.

## **Preliminary Work**

The rate of a reaction is found by measuring the amount of a Reactant used up per unit of time or the amount of Product produced per unit of time: -



The Effect of Surface Area: In many reactions, one of the reactants is a solid. The reaction between hydrochloric acid and calcium carbonate is one example. The experiment was carried out twice with the use of small chips and big chips. Carbon – dioxide is the gas produced. When both experiments were carried out a graph was drawn to go with the results.

There are 3 things that can be noticed from the graph:

- Curve 2 is steeper than curve 1, which immediately shows that the reaction is faster for the smaller chips.
- In both experiments, the final loss in mass is 2gms, which means 2gms of carbon dioxide is produced each time.
- For the small chips, the reaction is complete in 4mins, and for the large chips, it lasts for 6mins.

**THE RATE OF A REACTION INCREASES WHEN THE SURFACE AREA OF A SOLID REACTANT IS INCREASED.**

**IF A COLLISION IS TO TAKE PLACE THEN IT SHOULD HAVE SUFFICIENT ENERGY TO DO SO, IF IT DOESN'T THEN THE ACID PARTICLE WILL BOUNCE AWAY FROM THE REACTANT RESULTING IN NO REACTION.**

**THE MORE ACID PARTICLES THERE ARE, THE MORE SUCCESSFUL COLLISIONS THERE ARE, THEREFORE RESULTING IN A FASTER REACTION.**

Elements that can change the rate of a reaction are:

- An increase in temperature
- An increase in the surface area
- Smaller solid reactants, exposing more atoms.

This preliminary work helped me with doing my actual investigation by giving me a chance to choose which size marble chips I will use for the investigation. The three main parts written in bold above and the three

bullet points helped me in making my final decision, on what size marble chips to use, what concentration of acid to use and what temperature to do the experiment at. From this I finally decided to use medium size marble chips as this was a choice from large, medium and small, so using the medium sized chips would be fair. The concentration of acid which I finally decided to use was a range of 1M – 2.5M; this is because I would get a good range of results as well as it showing the rates of reaction increasing with the concentration of acid. If I would have used anything more concentrated then the rates of reaction would be too quick for me to get a good amount of results to do any conclusions from. The temperature of the experiment was decided to be done at room temperature, because if we had decided to do the temperature to another degree, then there would be no guarantee that I would be able to keep the temperature constant. If the temperature was to change then it would affect the rate of reaction, making it faster for some and slower for others, therefore making the results unreliable and inaccurate.

## Analysing Evidence & Drawing Conclusions

By looking at the graph you can quite easily see that from the four lines drawn, what I had predicted about the more concentrated acid will react quicker is true. From the graph you can see that the 1M and 1.5M acids are still reacting, as the lines do not straighten out into a plateau, unlike the 2M and 2.5M which do, showing that they have almost all reacted.

In my prediction, I also predicted that the 2M acid should react twice as fast then a 1M acid. This wasn't really correct in all cases, but from 70 seconds and onwards this prediction is almost true. There is a small difference of maybe 2 or 3, but besides that, the results show that the 2M acid is reacting more or less twice as fast then the 1M acid.

70	22	24	25	24
80	26	27	28	27
90	30	31	31	31
100	36	37	36	36
110	39	40	40	40
120	43	45	44	44
130	46	49	45	46
140	50	52	51	51
150	53	54	55	54
160	58	59	60	59
170	60	63	63	63
180	61	66	65	66

70	48	50	50	50
80	55	57	58	57
90	62	65	66	66
100	70	73	75	73
110	79	81	82	81
120	88	87	91	88
130	96	94	97	96
140	100	103	100	100
150	103	103	102	103
160	104	104	102	103
170	105	104	103	104
180	105	105	103	104

The

tables on the previous page are the results that I got after the investigation. The squares that are red are anomalous results. The first

column on each table represents the time, at 10 second intervals, the three columns after that represent, the results after three times, and the final column represents, the average.

In my prediction, I predicted that the 2.5M acid would react the fastest, and the 1M acid the slowest, and also that the 2M acid would react twice as fast as the 1M acid. As you can see from my results that for most cases my prediction was correct, and this is also backed up by the graph. As you can see that the more concentrated the acid, the steeper the curve is, showing a quicker reaction. This is down to the amount of acid particles in each of the acids. In a more concentrated acid there are more acid particles therefore resulting in a quicker reaction, and in a less concentrated acid there aren't as many acid particles, which means, less collisions and a slower reaction.

In the graph, you can see that the line for the 1M acid is still rising, which means that it is still reacting, and the line for the 2.5M acid, has risen quickly then slowly flattened out to a plateau, which means almost all the acid particles have reacted with the calcium carbonate.

## **Evaluation**

Overall, I thought that the investigation was good, and that my results were good, which allowed me to write up a decent conclusion.

The accuracy of this experiment was reasonably accurate, until the results passed the 100 mark, because that is all the measuring cylinders went up to, so we had to estimate the answers, which made the results a little inaccurate. We carried out the investigation three times for each of the acids and then took an average. To make the results as accurate as possible, any anomalous results were discounted to get as many results the same. For each time we did the investigation, we used the same equipment, following the same method making it a fair test. We highlighted our anomalous results, and didn't include them in our calculations of the overall average. The anomalous results were different to all the other results, and did not fit the overall pattern or trend of the others. All the acids had some anomalous results, but the 1.5M acid tended to have the most anomalous results. The anomalous results could have been caused by a number of things with the main one being the surface area of the chips and also the temperatures the investigation was carried out under.

The method used to carry out the investigation, was reasonably simple but very effective. The reason why it was satisfying was because it gave a set of reliable and satisfactory results. I am very satisfied with the reliability of the results, as they more or less matched my predicted results. I kept my investigation as accurate as possible by controlling the

method and fairness of the investigation, and the reliability was also good because I believe I determined a very good conclusion.

There are one or two improvements that could have been made to the investigation, and one of them is the accuracy of the measuring cylinders, seeing as they only went up to 100, any results after that had to be estimated. Another improvement could have been to the chips used, even though the same amount had been used and they had been weighed to the same weight every time, they were still not exactly the same. One other improvement could have been to have done the investigation in one day at the same temperature. The investigation was done over a period of two days, which meant that there would be a change in the temperature, and if the room was hotter on one day than the other, then that could cause the acid to react faster because it is hot and gaining energy. Besides these three improvements the investigation was ok. My conclusion is only valid for the range of acids I used, so for some further work, I would do the investigation using more acids. Other things that can be done are to do the investigation under different temperatures, or use different sized marble chips, or even use more acid. As an alternative, the investigation could be done using different materials, such as magnesium ribbon.

Overall, I was happy with the investigation and my results.