Order of reaction with respect to sodium thiosulphate biology essay

To study the effect of reactant concentration on the rate of the reaction between sodium thiosulphate and hydrochloric acid AND to determine the order of sodium thiosulphate.

The reaction used in this experiment is between dilute hydrochloric acid and sodium thiosulphate (formula Na2S2O3). You can see from the chemical equation below that one of the products is sulphur, which does not dissolve in water.

As the reaction proceeds, a fine precipitate of sulphur forms, which makes the water go cloudy. If the reaction is carried out in a beaker standing on a piece of paper marked with an X, the precipitate eventually becomes thick enough to stop the X from being seen. We can time how long it takes for the X to disappear for different concentrations of the sodium thiosulphate solution. This will show us how the reaction rate changes with concentration.

I will be progressively changing the concentration of sodium thiosulphate by adding increasing amounts of water each time in order to dilute the substance. The volume of water will be increased by 20cm3 and volume of sodium thiosulphate decreased by 20cm3 each time, keeping the total volume fixed at 120cm3.

Dependant Variable:

I will be observing the rate of formation of sulphur particles from the reaction between sodium thiosulphate and hydrochloric acid, which will cause the solution to go cloudy as the reaction progresses. This will be measured by timing how long it takes for the cross on the sheet of paper to become obscure.

Controlled Variable:

The temperature of the solution will have to be kept constant as it will affect its rate of reaction. Temperature is nothing but the measure of kinetic energy and if the temperature were to change it would mean that there would be more or less molecules with sufficient energy to react. This is a major problem which will generate some anomalies in the results and is quite hard to rectify without proper equipment but to be sure it did not affect the results I measured the temperature before and after the experiment and found no drastic change in the temperature of the room. The concentration of hydrochloric acid will also be kept constant in order to maintain a fair test as we will be observing the effects of the change in concentration of sodium thiosulphate. The volume will also be kept constant, to ensure that the [Na2S2O3 (aq)] is proportional to the volume of its solution used.

Procedure:

Volume of 2M HCl

(cm3)

Volume of 0. 15M Na2S2O3 (cm3)

Volume of distilled water

(cm3)

20

100

0

20

80

20

20

60

40

20

40

60

20

20

80

20

0

100

1. Label one of the 400cm3 beakers ‘ THIO’ and collect in it about 320cm3 of 0. 15M sodium thiosulphate solution.

2. Label the other 400cm3 beaker ‘ WATER’ and collect in it about 310cm3 of distilled water.

3. Label one of the 250cm3 beakers ‘ ACID’ and collect in it about 140cm3 of 1M hydrochloric acid.

Use the (100cm3) measuring cylinder to measure out 100cm3 of 0. 15M sodium thiosulphate and pour this into the remaining EMPTY 250cm3 beaker and stand it on the paper marked with an X.

Use the second (100cm3) measuring cylinder to measure out 20cm3 of 1M hydrochloric acid. Quickly pour the acid into the beaker standing on the cross and start the clock.

Look down at the X through the solution in the beaker. As soon as the X disappears completely, stop the clock and record the time taken in seconds in the results table.

7. Rinse out the beaker well and dry it. Reset the clock. Repeat the experiment with different concentrations of sodium thiosulphate – make these up according to the instructions given in the above table.

Result:

Quantitative raw & processed data

HCl/cm3 (±0. 5cm3)

Water/cm3 (±0. 5cm3)

Sodium Thiosulphate/cm3 (±0. 5cm3)

Time/sec (±1s)

Average Time/sec(±1s)

20

0

100

64

62

40

55. 33

20

20

80

76

91

45

70. 67

20

40

60

97

103

66

88. 67

20

60

40

153

149

100

134. 00

20

80

20

351

348

235

311. 33

20

100

0

â^ž

â^ž

â^ž

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During the reaction between the two clear solutions, sodium thiosulphate and hydrochloric acid, produced a yellow precipitate of sulphur, which caused the solution to go opaque and obscure the black cross drawn on the white sheet of paper. After completely reacting, the black cross was no longer visible.

Successfully gathering the data, now I will try to find the order of the reaction with respect to sodium thiosulphate through

Initial Rate Method

The initial rate method is conveniently employed for clock reactions in which one or more components exhibit periodic change. For each experiment (corresponding to each initial concentration of reactant) the time taken for a definite, small amount of a product to be formed at the start of the reaction (when its rate is most rapid) is measured. This gives a measure of the initial rate of the reaction because the shorter the time taken for it to form, the faster the rate.

So Reaction rate = Fixed amount of reaction

Time taken

As we can see rate and time are inversely related, or rate µ 1/time. A rate against concentration curve is obtained by plotting 1/t against volume, revealing the order of reaction with respect to the reactant concerned as in fig. 1

Volume/cm3 (±0. 5cm3)

Initial Rate /s-1 (±4%)

100

1. 8 x 10-2

80

1. 4 x 10-2

60

1. 1 x 10-2

40

0. 7 x 10-2

20

0. 3 x 10-2

0

0

(Graph in separate sheet.)

After plotting the graph and drawing a line of best fit, the order of reaction with respect to sodium thiosulphate will be evident.

Conclusion:

The graph shows a linear plot, which means that the order of reaction with respect to sodium thiosulphate is one. Thus our rate law will look like this

Rate âˆ [N2S2O3], which can also be written as Rate = k [N2S2O3]1

Although there are a few complications with the degree of accuracy of the collected data which is mostly down to random rather than systematic error as the disappearance of the cross was fairly judged by sight and also the delay in stopping the clock. I would say that the total random errors generated a tolerance of ±3%. Still I stand by my table of results which show that the reaction proceeded much slower when the concentration was decreased due to the less number of particles per unit volume, lowering the chance of a successful collision between molecules. As the frequency of collisions decreased, the rate of reaction decreased, slowing down the rate of formation of sulphur, thereby increasing the amount of time measured. My graph also verifies this as there is a positive correlation between concentration and rate, meaning that if the concentration were to decreases by half the rate would also decrease by half, hence increasing the time measured for the formation of sulphur.

Evaluation:

Not all of my results were dependable, I believe that the experiment was successful but there were some unreliable or anomalous results which were not expected, which is due to the fact that there was a higher concentration than the one noted. I repeated the experiment three times and took an average value to ensure the results were accurate but although most of the results from each experiment were similar, there were still some irregularities.

If I were to do the experiment again, I would use a burette to measure the correct volumes of sodium thiosulphate and hydrochloric acid. I realised that I may not have been precise enough when using the measuring cylinder. To further improve quality and precision of the results, I would use a light meter to measure the amount of light left in the reaction rather than visually judging when the cross has disappeared.

The only anomaly was during the third experiment where the readings were way off from the first two, which could be due to the fact that I did not use a stock solution of hydrochloric acid or perhaps from improper cleaning of the equipment on reuse.