Rate Of Reaction In Sodium Thiosulphate And HCl Essay, Research Paper

Plan We

must produce a piece of coursework investigating the rates of reaction, and the

effect different changes have on them. The rate of reaction is the rate of loss

of a reactant or the rate of formation of a product during a chemical reaction.

It is measured by dividing 1 by the time taken for the reaction to take place.

There is five factors which affect the rate of a reaction, according to the

collision theory of reacting particles: temperature, concentration (of

solution), pressure (in gases), surface are (of solid reactants), and

catalysts. I have chosen to investigate the effect temperature and

concentration have on a reaction. This is because they are the most practical

to investigate ? it would take longer to prepare a solid in powdered and

unpowdered form, and it is difficult to get accurate readings due to the

inevitabilities of human errors, and as gas is mostly colourless it is difficult

to gauge a reaction changing the pressure, and if a substance is added to give

the gas colour, it may influence the outcome of the experiment. Similarly the

use of a catalyst complicates things, and if used incorrectly could alter the

outcome of the experiment.

Aim: –

To see the effects of a change in temperature and concentration on the rate of

a reaction. The reaction that will be used is:

Sodium Thiosulphate + Hydrochloric Acid

Na2S2O3 (aq) + 2HCl (aq)

Sodium Chloride + Water + Sulphur Dioxide +

2NaCl (aq) + H2O (l) + SO2 (g) +

Sulphur

S (s)

Two series of experiments will be carried out ? one changing the temperature

(while everything else remains constant) and one varying the concentration

(while keeping everything else constant). Both the sodium thiosulphate and the

Hydrochloric acid are soluble in water, so the concentration of either can be

changed. However I have chosen to vary the sodium thiosulphate as it is

available in larger amounts, and various concentrations are prepared. When the

temperature is constant room temperature will be used as the temperature as it

more practical and will not need to be monitored. When the temperature is being

varied a water bath will be used to heat up the acid and thiosulphate to the

necessary temperature.

I decided which temperatures and concentrations to use during my preliminary

series of experiments ?

1 mol/dm3 of HCl (acid concentration will be fixed)

10-35g/dm3 of sodium thiosulphate (all of these concentrations will be tested

in turn going up in steps of 5g/dm3)

20-70°C temperature (all of these temperatures will be used going up in steps

of 10°C)

Concentrations of 5, and 40 g/dm3 of thiosulphate were available to me but my

preliminary work showed that the 5 g/dm3 and 40g/dm3 were too slow and fast

respectively in reacting to be worth testing. Similarly any temperature below

20°C reacted too slowly, and 80°C and 90°C reacted too quickly to be worth

including in my final results.

Using my preliminary experiments I decided on using the following apparatus:

1 thermometer

1 beaker

2 measuring cylinders

1 conical flask

1 tripod

1 gauze

1 heatproof mat

1 stopwatch

1 Bunsen burner

X board

1 pair of tongs

1 pair of goggles

1 apron

Method: –

Experiment 1 – Changing the concentration

5 cm3 of HCl (at concentration 1 mol./dm3) and 15 cm3 of sodium thiosulphate

(at varying concentrations ? 10 to 35 g/dm3) are poured out into two measuring

cylinders and then poured into a conical flask, which is placed on top of a

board marked with letter X. The stopwatch will now be started. When the mixture

has turned sufficiently cloudy so that the letter X can no longer be seen the

stopwatch will be stopped and the time will be recorded. The experiment is

repeated with all the concentrations. The whole procedure is then repeated.

Experiment 2 ? Changing the temperature

5 cm of HCl (at concentration 1 mol./dm3) and 15 cm of sodium thiosulphate (at

varying concentrations ? 10 to 35 g/dm3) are poured out into two measuring

cylinders. A beaker is half filled with hot water from a tap. The water is

placed on top of a Bunsen on a blue flame and the two measuring placed inside

the water bath. The water is heated to the necessary temperature (30°C to 70°C)

then the two measuring cylinders are taken out and the contents of both are

poured into a conical cylinder. The time it takes for the X to disappear is

timed and recorded. The experiment is repeated using all the temperatures. The

entire procedure is the repeated.

Repeat results and averages will be taken to improve the credibility of the

findings, and present solid grounding for the final conclusion. The repeat

results will help to iron out any anomalies and the average will give a good

summary of the results of the experiment. However if one set of results is

entirely different to the other, a third experiment will be performed to

replace the anomalous set of results.

Safety ? A pair of goggles will be worn during the heating part of the

experiment in order to protect the eyes. An apron will also be worn to protect

the skin and clothing. When handling hot beakers and measuring cylinders a pair

of tongs will be used. A gauze and heatproof mat will be used while heating to

avoid any damage to the equipment.

Fair Test – In order for my findings to be valid the experiment must be a fair

one. I will use the same standard each time for judging when the X has

disappeared. I will make sure that the measuring cylinders for the HCl and

thiosulphate will not be mixed up. The amount of HCl will be 5 cm3 each time,

and the amount of thiosulphate will be fixed at 15 cm3. During the heating

stage of the experiment, a blue flame will be used throughout. Also the same

Bunsen burner and gas tap will be used to maintain continuity. All of these

precautions will make my final results more reliable and keep anomalies at a

minimum so thus make the entire investigation more successful.

Prediction ?

I predict that as the temperature is increased the rate of reaction will

increase. I also predict that as the concentration of the sodium thiosulphate

increases the rate of reaction will increase. This means that both graphs drawn

up in my analysis will have positive correlation, and will probably be curved

as the increase in rate of reaction will not be exactly the same as the concentration\temperature

is increased. This can be justified by relating to the collision theory. When

the temperature is increased the particles will have more energy and thus move

faster. Therefore they will collide more often and with more energy. Particles

with more energy are more likely to overcome the activation energy barrier to

reaction and thus react successfully. If solutions of reacting particles are

made more concentrated there are more particles per unit volume. Collisions

between reacting particles are therefore more likely to occur. All this can be

understood better with full understanding of the collision theory itself:

For a reaction to occur particles have to collide with each other. Only a small

percent result in a reaction. This is due to the energy barrier to overcome.

Only particles with enough energy to overcome the barrier will react after

colliding. The minimum energy that a particle must have to overcome the barrier

is called the activation energy, or Ea. The size of this activation energy is

different for different reactions. If the frequency of collisions is increased

the rate of reaction will increase. However the percent of successful

collisions remains the same. An increase in the frequency of collisions can be

achieved by increasing the concentration, pressure, or surface area.

Concentration ? If the concentration of a solution is increased there are more

reactant particles per unit volume. This increases the probability of reactant

particles colliding with each other.

Pressure – If the pressure is increased the particles in the gas are pushed

closer. This increases the concentration and thus the rate of reaction.

Surface Area ? If a solid is powdered then there is a greater surface area

available for a reaction, compared to the same mass of unpowdered solid. Only

particles on the surface of the solid will be able to undergo collisions with

the particles in a solution or gas.The particles in a gas undergo random

collisions in which energy is transferred between the colliding particles. As a

result there will be particles with differing energies. Maxwell-Boltzmann

energy distribution curves show the distribution of the energies of the

particles in a gas.

The main points to note about the curves are:

1. There are no particles with zero energy.

2. The curve does not touch the x-axis at the higher end, because there will

always be some particles with very high energies.

3. The area under the curve is equal to the total number of particles in the

system.

4. The peak of the curve indicates the most probable energy.

The activation energy for a given reaction can be marked on the distribution

curve. Only particles with energy equal or greater than the activation energy

can react when a collision occurs.

Although Maxwell-Boltzmann distribution curves are for the particles in a gas,

the same distributions can be used for the particles in a liquid or solid.

Effects of a temperature change – The graph below shows Maxwell-Boltzmann

distribution graphs for a fixed mass of gas at two temperatures ? T1 and T2,

where T2 is roughly 10°C higher than T1. The total area under the curve remains

the same, since there is no change in the number of particles present.

A small increase in temperature causes significant changes to the distribution

energies. At the higher temperature:

1. The peak is at a higher energy.

2. The peak is lower.

3. The peak is broader.

4. There is a large increase in the number of particles with higher energies.

It is the final change that results increase in rate, even with a relatively

small increase in temperature. A small increase in temperature greatly

increases the number of particles with energy greater than the activation

energy. The shaded areas on the energy distribution curves show this.

Effect of a catalyst – A catalyst works by providing an alternative reaction

pathway that has lower activation energy. A catalyst does not alter the

Maxwell-Boltzmann distribution. Because a catalyst provides a reaction route of

lower activation energy, however, a greater proportion of particles will have

energy greater than the activation energy.

Secondary Sources Used:

AS Level Chemistry Textbook (kinetics module)

The Internet

Dr. Jones?s Chemistry Lessons

Information sheets from Dr. Jones

Obtaining Evidence

Temp.(°C)???????? Time 1 (s)???????? Time 2 (s)??????? Average (s)

20??????????????????? 110.67????????????? 107.42????????????? 109.045

30??????????????????? 100.13????????????? 103.34????????????? 101.735

40??????????????????? 64.20?????????????? 65.92????? ??????????65.06

50??????????????????? 45.34?????????????? 37.73??????????????? 41.535

60??????????????????? 30.12??????????????? 33.18??????????????? 31.65

70???????????????????? 18.92?????????????? 16.34??????????????? 17.63

Concen.(g/dm3)???? Time 1 (s)?????? Time 2 (s)???? Average (s)

10???????????????????????? 222.63??????????? 224.38????????? 223.505

15???????????????????????? 150.90???????????? 147.03?????????? 148.965

20???????????????????????? 105.25??????????? 105.97?????????? 105.61

25??????? ?????????????????66.04?????????????

68.75??????????? 67.395

30???????????????????????? 55.63????????????? 56.1?????????????? 55.865

35???????????????????????? 27.32????????????? 25.96??????????? 26.64

Temp.(°C)? Rate of Reaction 1(s-1)?? Rate of Reaction 2 (s-1)? Average (s-1)

20???????????? 0.00904????????????????????????? 0.00931?????????????????????????? 0.00917

30???????????? 0.00999????????????????????????? 0.00968?????????????????????????? 0.00983

40???????????? 0.01558????????????????????????? 0.01517??????????????????????????? 0.01537

50????????????? 0.02206???????????????????????? 0.02650?????????????????????????? 0.02428

60????????????? 0.03320???????????????????????? 0.03014??????????????????????????? 0.03167

70????????????? 0.05285??????????? ?????????????0.06120??????????????????????????? 0.05703

Concen.(g/dm3)?? Rate of Reaction

1(s-1)?? Rate of Reaction 2 (s-1)?? Average (s-1)

10.00000??????????????? ?0.00449????????????

?0.00446 ???????????????????????0.00447

15.00000??????????????? ?0.00663 ?????????????0.00680 ???????????????????????0.00671

20.00000??????????????? ?0.00950????????????

?0.00944????????????????????? ??0.00947

25.00000 ????????????????0.01514 ?????????????0.01455???????????????????????? 0.01484

30.00000??????????????? ?0.01798 ?????????????0.01783?????????????????????? ??0.01790

35.00000??????????????? ?0.03660 ?????????????0.03852 ???????????????????????0.03756

Temp.(°C)??? Rate of Reaction 1(s)

x1000?? Rate of Reaction 2 (s)

x1000??? Average (s)

20????????????????? ????9.04????????????????????????????????????????????????? 9.31???????????????????????????? 9.17

30????????????????????? 9.99?????????????????????????????????????????????????

9.68???????????????????????????

9.83

40???????????????????? 15.58???????????????? ?????????????????????????????????15.17???????????????????????? 15.37

50??????????????????? 22.06?????????????????????????????????????????????????

26.50???????????????????????

24.28

60??????????????????? 33.20???????????????????????????????????????????????

??30.14???????????????????????? 31.67

70??????????????????? 52.85?????????????????????????????????????????????????

61.20???????????????????????

57.03

Concen.(g/dm)??? Rate of Reaction 1(s)

x1000??? Rate of Reaction 2 (s)

x1000? Average (s)

10???????????? ??????????????????????????4.49???????????????????????????????????????

4.46?????????????????????????

4.47

15??????????????????????????????????????

6.63??????????????????????????????????????? 6.80????????????????????????? 6.71

20???????????????????????????? ??????????9.50?????????????????????????????????????? 9.44?????????????????????????? 9.47

25??????????????????????????????????????

15.14????????????????????????????????????? 14.55???????????????????????? 14.84

30??????????????????????????????????????

17.98 ?????????????????????????????????????17.83???????????????????????? 17.90

35??????????????????????????????????????

36.60???????????????????????????????????? 38.52???????????????????????? 37.56

Analysis

In this experiment I have found that as the temperature and concentration is

increased the time taken for the reaction to take place decreases. This means

the rate of reaction increasers as it takes less time for a reaction to take

place, so more take place per second. In the temperature experiment the time taken

for a reaction to take place decreased by roughly 10 to 15 seconds for every

10°C increase in temperature, with the one anomaly being the 30°C reading.

There is also a trend in the increase in rate of reaction as the temperature

increases. The difference is always more or less 0.02 s-1, with the same

exception.

Using the graphs, with lines of best fit, I can draw a conclusion from my

experiment. Firstly I can see that with the ?time? graphs (that plot

temperature and concentration against time taken for the reaction to take

place) the graphs have negative correlation in both cases, meaning that as the

temperature\concentration increased the time taken for the reaction to take

place decreases. The time graph for the temperature experiment has a much

steeper curve than the one for the concentration experiment, meaning that the

decrease in time taken for the reaction was far more rapid.

Naturally, the above means that the both the graphs plotting rate against

temperature and concentration have positive correlation ? as the temperature

and concentration are increased so does the rate of reaction. This is because

when the temperature is increased the particles will have more energy and thus

move faster. Therefore they will collide more often and with more energy.

Particles with more energy are more likely to overcome the activation energy

barrier to reaction and thus react successfully, and when solutions of reacting

particles are made more concentrated there are more particles per unit volume.

Collisions between reacting particles are therefore more likely to occur.

The graph for concentration shows that when the concentrations were relatively

low (10, 15, 20 g/dm3), the increase of rate x1000 was also fairly small

(increasing from 4.47 to 6.71 to 9.47). There was then a gradual increase in

the difference, and between 30 and 35 g/dm3 the rate more than doubled from

17.90 to 37.56s-1. This shows that there are far more collisions at a

concentration of 35 g/dm3 than at 30 g/dm3.

The graph plotting time against the rate of reaction x1000 shows that the

difference of rate between increasing temperatures (excluding the anomaly of

30°C) was pretty much regular, increasing in steps of 6-10 (9.17 to 15.37 to

24.28 to 31.67). However, once again there is a giant gap in the last

temperature increase ? at 60°C the RoR x1000 is 31.67 s-1, and at 70°C it is

57.03 s-1.

For this to fully make sense it is necessary to recap the collision theory

briefly:

For a reaction to occur particles have to collide with each other. Only a small

percent result in a reaction. This is due to the energy barrier to overcome.

Only particles with enough energy to overcome the barrier will react after

colliding. The minimum energy that a particle must have to overcome the barrier

is called the activation energy, or Ea. The size of this activation energy is

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