Rates Of Reaction Essay, Research Paper

Rates of Reaction

BACKGROUND INFORMATION

What affects the rate of reaction? 1) The surface area of the magnesium. 2)

The temperature of the reaction. 3) Concentration of the hydrochloric acid. 4)

Presence of a catalyst.

In the experiment we use hydrochloric acid which reacts with the magnesium to

form magnesium chloride. The hydrogen ions give hydrochloric acid its acidic

properties, so that all solutions of hydrogen chloride and water have a sour

taste; corrode active metals, forming metal chlorides and hydrogen; turn litmus

red; neutralise alkalis; and react with salts of weak acids, forming chlorides

and the weak acids.

Magnesium, symbol Mg, silvery white metallic element that is relatively

unreactive. In group 2 (or IIa) of the periodic table, magnesium is one of the

alkaline earth metals. The atomic number of magnesium is 12.

Magnesium(s) + Hydrochloric acid(aq) = Magnesium Chloride(aq) + Hydrogen(g)

Mg + 2HCl= MgCl2

+ H2

In the reaction when the magnesium hits the acid when dropped in, it fisses and

then disappears giving of hydrogen as it fisses and it leaves behind a solution

of hydrogen chloride.

The activation energy of a particle is increased with heat. The particles

which have to have the activation energy are those particles which are moving,

in the case of magnesium and hydrochloric acid, it is the hydrochloric acid

particles which have to have the activation energy because they are the ones

that are moving and bombarding the magnesium particles to produce magnesium

chloride.

The rate at which all reactions happen are different. An example of a fast

reaction is an explosion, and an example of a slow reaction is rusting. In any

reaction, reactants chemical reactions? products.

We can measure reactions in two ways:

1) Continuous:- Start the experiment and watch it happen; you can use a

computer ?logging? system to monitor it. I.e. Watching a colour fade or

increase.

2) Discontinuous:- Do the experiments and take readings/ samples from the

experiment at different times, then analyse the readings/samples to see how many

reactants and products are used up/ produced.

Reaction rate = amount of reactant used up

time taken

If the amount used up is the same each time then the only thing that changes is

the time taken.

so, reaction rate ? 1

time taken.

rate = K

time taken.

Where K is the constant for the reaction.

For particles to react:-

a) They have to collide with each other. b) They need a certain amount of

energy to break down the bonds of the particles and form new ones. This energy

is called the ?Activation Energy? or Ea.

When we increase the temperature we give the particles more energy which:

1) Makes them move faster which In turn makes them collide with each other more

often.

2) Increases the average amount of energy particles have so more particles have

the ?activation energy?

Both of these changes make the rate of reaction go up so we see a decrease in

the amount of time taken for the reaction and an increase in time taken.

= 1

Time taken reflects the rate of reaction.

Because temperature has an effect on both the speeds at which the particles

react and the activation energy they have a greater effect on the rate of

reaction than other changes.

A change in concentration is a change in the number of particles in a given

volume.

If we increase the volume:-a) The particles are more crowded so they collide

more often.

b) Although the average amount of energy possessed by a particle does not

change, there are more particles with each amount of energy;- more particles

with the activation energy.

a) is a major effect which effects the rate, but b) is a minor effect which

effects the rate very slightly.

In this experiment we are not concerned with whether the reaction is

exothermic or endothermic because we are concerned with the activation energy

needed to start and continue the reaction.

PREDICTIONS

I predict that as we increase the temperature the rate of reaction will

increase.

If we increase the temperature by 100C the rate of reaction will double.

I predict that if we increase the concentration of the acid the reaction rate

will increase.

If the concentration of the acid doubles, the rate of the reaction will also

double.

LINKING PREDICTION TO THEORY

Reaction Rate and Temperature.

The collision theory describes how the rate of reaction increases as the

temperature increases. This theory states that as the temperature rises, more

energy is given to the particles so their speed increases, this increases the

number of collisions per unit of time. This increase in collisions increases

the rate of reaction.

The collision theory explains how the rate of reaction increases, but it does

not explain by how much or by how fast the rate increases. The Kinetic energy of

a particle is proportional to its absolute (Kelvin) temperature.

1/2 mv2? T

But the mass of the particles remains constant so we can eliminate that part of

the equation so;

? V2?T

Therefore we can fit this into a formula:

V21/V22 = T1/T2

If we substitute the temperature into the formula we can work out the average

speed of the formula:

V21/V22 = 310/300

\V 1= ?310/300V 2

= ?1.033V2

= 1.016V2

However if we look at this it is only 1.016 times greater than the speed at

300K, in other words we can see that it has only increased by 1.6%.

The frequency of the collisions depends on the speed of the particles, this

simple collision theory only accounts for the 1.6% increase in the rate, but in

practice the reaction rate roughly doubles in a 10K rise, so this simple theory

cannot account for an 100% increase in the reaction rate.

During a chemical reaction the particles have to collide with enough energy to

first break the bonds and then to form the new bonds and the rearranged

electrons, so it is ?safe? to assume that some of the particles do not have

enough energy to react when they collide.

The minimum amount of energy that is needed to break down the bonds is called

the activation energy (EA). If the activation energy is high only a small

amount of particles will have enough energy to react so the reaction rate would

be very small, however, if the activation energy is very low the number of

particles with that amount of energy will be high so the reaction rate would be

higher. An example of a low EA would be in explosives when they need only a

small input of energy to start their exceedingly exothermic reactions.

In gases the energy of the particles is mainly kinetic, however in a solid of a

given mass this amount of energy is determined by their velocities.

This graph below shows how the energies of particles are distributed.

This graph is basically a histogram showing the number of particles with that

amount of energy. The area underneath the curve is proportional to the total

number of particles. The number of particles with > EA is proportional to the

total area underneath the curve.

The fraction of particles with > EA is given by the ratio:

Crosshatched area under the curve

total area under curve

Using the probability theory and the kinetic theory of gases, equations were

derived for the distribution of kinetic energy amongst particles. From these

equations the fractions of particles with an energy > EA J mole-1 is represented

by the equation: e -Ea/RT where R= the gas constant (8.3 J K-1 mole -1)

T= absolute temperature.

This suggests that at a given temperature, T,

The reaction rate ? e -Ea/RT

If we use k as the rate constant, as a measure of the reaction rate we can put

this into the equation also.

k? e -Ea/RT

? k= A e -Ea/RT

The last expression is called the Arrhenius equation because it was developed

by Srante Arrhenius in 1889. In this equation A can be determined by the total

numbers of collisions per unit time and the orientation of the molecules when

the collide, whilst e -Ea/RT is determined by the fraction of molecules with

sufficient amounts of energy to react.

Putting the probability theory and the kinetic theory together this now gives

us a statement which accounts for the 100% increase in the rate of reaction in a

10K rise.

Reaction Rate and Concentration.

The reaction rate increases when the concentration of the acid increases

because:

If you increase the concentration of the acid you are introducing more particles

into the reaction which will in turn produce a faster reaction because there

will be more collisions between the particles which is what increases the

reaction rate.

METHOD.

To get the amount of magnesium and the amount of hydrochloric acid to use in

the reaction, we have to use an excess of acid so that all of the magnesium

disappears.

Mg + 2HCl= MgCl2

+ H2

1 mole 2 moles1 mole

1 mole

So, we can say that one mole of magnesium reacts with 2 moles of hydrochloric

acid.

If we use 1 mole of magnesium and 2 moles of hydrochloric acid we will get a

huge amount of gas, too much for us to measure. We would get 24,000 cm3 of

hydrogen produced where we only want 100 cm3 of hydrogen produced. So to get

the formula for the amount of moles that we have to use the formula:

Moles = mass of sample 100=0.004 moles.

volume with 1 mole24,000

To get the maximum mass we can use:

Mass = moles x RAM.

= 0.004 x 24

= 0.0096g

So, this is the maximum amount of magnesium we can use. To the nearest 0.01 of

a gram = 0.01. This is the maximum amount of magnesium we can use.

Because the reaction reacts one mole of magnesium to two moles of hydrochloric

acid we have to make sure that even with the lowest concentration of acid we

still have an excess of acid.

The acid that we were using was 2 moles per dm2 which means that it is 0.2

moles per 100 cm2 of acid.

We need to make the reaction work to have double the amount of magnesium. The

maximum number of moles that the magnesium needed was 0.004 moles so the amount

of acid that we needed was double that so that equals 0.008 moles. As you can

see from the table below we have the acid in excess throughout the experiment.

Amount of HCl (cm3)Amount of H2O (cm3)Moles of acid. 1000

0.2 75250.15 50500.1 25750.05 The reason why we

used 0.01g of magnesium was because it was therefore easy to measure because

there was not too much, or too little. Therefore we had no problem with too

much gas.

Apparatus

This is the apparatus we used to measure the amount of H2 that was produced in

the reactions. We measured the amount of gas that was given of every two

seconds to get a good set of results. We used this apparatus with the reaction

changing the concentration, and then the temperature. To accurately measure the

amount of gas given of we used a pen and marked on the gas syringe at the time

intervals.

This is the apparatus we used to measure how long it took for the magnesium to

totally disappear. We used this apparatus in both of the experiments, changing

the temperature and the concentration of the acid to water.

Temperature.

When we did the experiment changing temperature we used both of the sets of

apparatus. To get a fair reaction we had to keep the amount of magnesium the

same and the concentration of the acid. In the experiment we used 0.1g of

magnesium and the concentration of the acid was 50cm3 of acid to 50cm3 of water.

This is because if we used 100cm3 of acid the reaction would be too fast. Still

we had an excess amount of acid, so one mole of magnesium can react with two

moles of HCl. Concentration.

When we did the reaction changing the concentration we changed the

concentration until we had just enough for 1 mole of magnesium to react with two

of HCl. To get a fair reaction we had to keep the amount of magnesium the same

and the temperature. We used 0.1g of magnesium.

RESULTS

Temperature

From this graph you can see that if we do increase the temperature the rate of

reaction also increases, but it does not show that if you increase the

temperature the rate of reaction doubles.

This graph shows that there is an increase in the rate of reaction as the

temperature increases. This shows a curve, mainly because our results were

inaccurate in a number of ways. This is because the concentration is changed

during the experiment because at high temperatures the acid around the magnesium

is diluted. If this experiment was accurate it would be also a curve but if you

made it into 1/time the result would be a straight line showing a clear

relationship.

Even though I changed it to 1/time it still does not show a clear relationship

because of the factors mentioned in the conclusion. Concentration

This graph shows an increase in the amount of gas given off and the speed at

which it is given off. This graph also does not show the rate increase, it just

shows how it increases with a change in concentration.

This graph shows that if you increase the concentration of the molar solution of

the acid the time in which the Mg takes to disappear becomes a lot slower. This

does not show the rate at which this happens, the graph of rate vs. conc. would

show a straight line.

This shows a straight line, thus proving that there is a relationship between

the time it takes the magnesium to disappear and the concentration of the acid.

If we take a gradient of it, it would show the rate at which the reaction was

happening.

Because this shows a straight line we can say that it is a second order

reaction.

This graph shows a nearly straight line which shows that there is a

relationship between the temperature and the rate of reaction, as the

gradient shows the rate of reaction. If you look at this graph it comes out to

show that if you increase the temperature by 100C the gradient of the line is

doubled. This shows that rate ? temp.

This graph shows that if you increase the molar concentration of the acid, you

will increase the rate of reaction. From this you can see from the gradient,

that if you double the molar concentration of the acid the rate of reaction will

double because the gradient is a way of showing the rate of reaction.

If you compare the quantitative observations to see which the faster reaction

is you can see that after 10 seconds: Temp.2102030

4050 Amount of H2 produced after 10s7.5162554

57 83

Even though there is a greater increase in the amount of H2 given off in each

of the different reactions you can see that there is a change in the amount

given off, but between the temperatures 30 and 400C there is not much of a

change, this could be because of our human error, there should be a big change

in the amount given off. Molar conc.0.511.52 Amount of H2

produced after 10s6256090 This table shows a nice

spread of results throughout the range of concentration. It clearly shows that

the reaction is at different stages so is therefore producing different amounts

of H2. This shows also that the reaction is affected by the concentration of

the acid.

CONCLUSIONS

I conclude that if you increase the temperature by 10oC the rate of reaction

would double, this is because of using the kinetic theory and the probability

theory. Even though our results did not accurately prove this, the theory that

backs it up is sufficient. the kinetic theory explains that if you provide the

particles with a greater amount of kinetic energy they will collide more often,

therefore there will be a greater amount of collisions per unit time. The

probability theory explains that there is only a number of particles within the

reaction with the amount of Ea to react, so if you increase the amount of

kinetic energy there will be more particles with that amount of Ea to react, so

this will also increase the reaction rate.

If you double the concentration of the acid the reaction rate would also double,

this is because there are more particles in the solution which would increase

the likelihood that they would hit the magnesium so the reaction rate would

increase. The graph gives us a good device to prove that if you double the

concentration the rate would also double. If you increase the number of

particles in the solution it is more likely that they will collide more often.

There should be more H2 given off if we compare it across the range of

temperatures because the reaction is going quicker and so more H2 is given off

in that amount of time.

There is more H2 given off if you compare it to the range of concentrations

that you are using, this shows that the reaction is at different stages and so

is therefore producing different amounts of H2.

Also our results were not accurate but this could be because of a number of

reasons.

There our many reasons why our results did not prove this point accurately. -

At high temperatures the acid around the magnesium starts to starts to dilute

quickly, so if you do not swirl the reaction the magnesium would be reacting

with the acid at a lower concentration which would alter the results. – Heating

the acid might allow H Cl to be given off, therefore also making the acid more

dilute which would also affect the results. – When the reaction takes place

bubbles of H2 are given off which might stay around the magnesium which

therefore reduces the surface area of the magnesium and so the acid can not

react properly with it so this affects the results.

To get more accurate results, we could have heated the acid to a lower

temperature to stop a large amount of H Cl being given off. The other main

thing that could have helped us to get more accurate results is we cold have

swirled the reaction throughout it to stop the diluting of the acid and the

bubbles of H2 being given off.

If I had time I could have done the reactions a few more times to get a better

set of results. This would have helped my graphs to show better readings.