Candidate 3 evidence

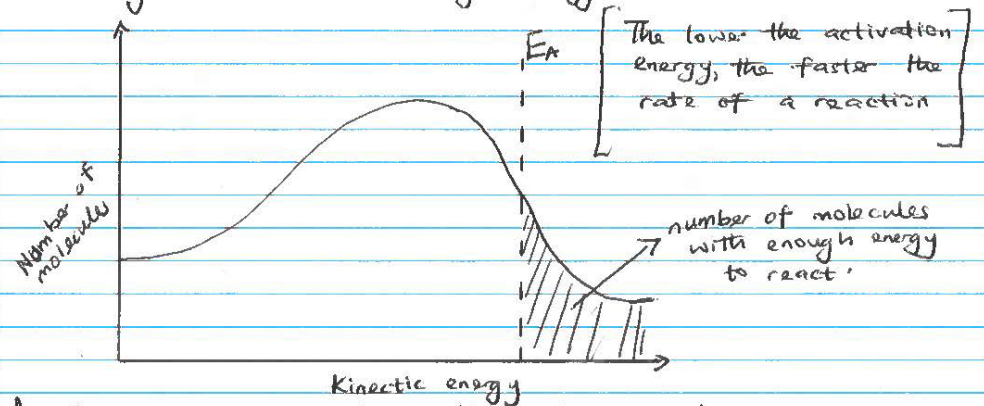
Title: Effect of Concentration on the Rate of a Reaction.

Aim: To determine the effect on the rate of the reaction between sodium thiosulfate solution and hydrochloric acid by changing concentration

Underlying Chemistry: The study of rates of reaction and factors that affect it is called 'Kinetics'. All substances are made of particles that are always in motion. The degree of movement depends on the state of the substance. This is known as the 'Kinetic model' of matter. In any sample of solution, liquid or gas there is a range of kinetic energies known as an energy distribution. Chemical reactions occur at different rates depending on the nature of the reaction and the conditions under which it occurs. Rate is very important to chemists. In the chemical industry, if reaction rate is too low, it can lead to insolvency and if too high, there is a risk of thermal explosion. The rate of reaction changes as it progresses, being relatively fast at the start and slowing towards the end. Average rate = change in variable / time and the unit depends on whatever variable is being measured.

For a reaction to occur, the reacting particles must collide (collision theory). Simple collision is not sufficient, the particles also need to have sufficient energy and correct geometry, without all these, successful collision cannot occur. When talking about sufficient energy, we look at the activation energy. This is the minimum kinetic energy required by colliding particles before reaction will occur.

By showing the activation energy on a graph, we can see how many molecules have enough energy to react.

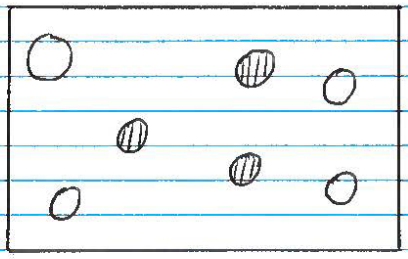


As the reactant molecules collide they must have enough energy to overcome the repulsive forces and start to break the bonds between the atoms.

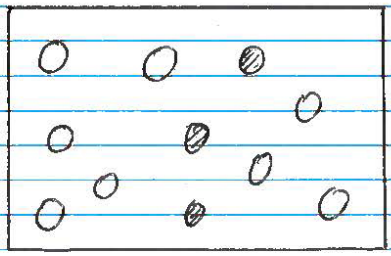
An intermediate stage is reached in which a higher energy, unstable arrangement of atoms is formed called the activated complex. The rate of a chemical reaction can be affected by so many factors such as temperature, concentration, pressure, particle size and catalyst. Only some collisions take place (successful collisions). The greater the number of successful collisions, the faster the rate of a reaction.

Concentration changes the number of particles per unit volume. if the concentration of reactants is increased, there are more reactant particles moving together. The more particles in a given volume, the greater the probability of them colliding. Hence, increasing the concentration increases the number of collisions per unit time and therefore increases the rate of reaction.
There are some situations where by changing concentration doesn't affect the reaction rate (this isn't common). Let's us say you are using a little amount of a solid catalyst in a reaction and a high concentration of reactant in the solution so that the catalyst surface is totally covered up with reacting particles. Increasing the concentration of the solution even more can't have any effect because the catalyst is already working at its maximum capacity (surface large area).

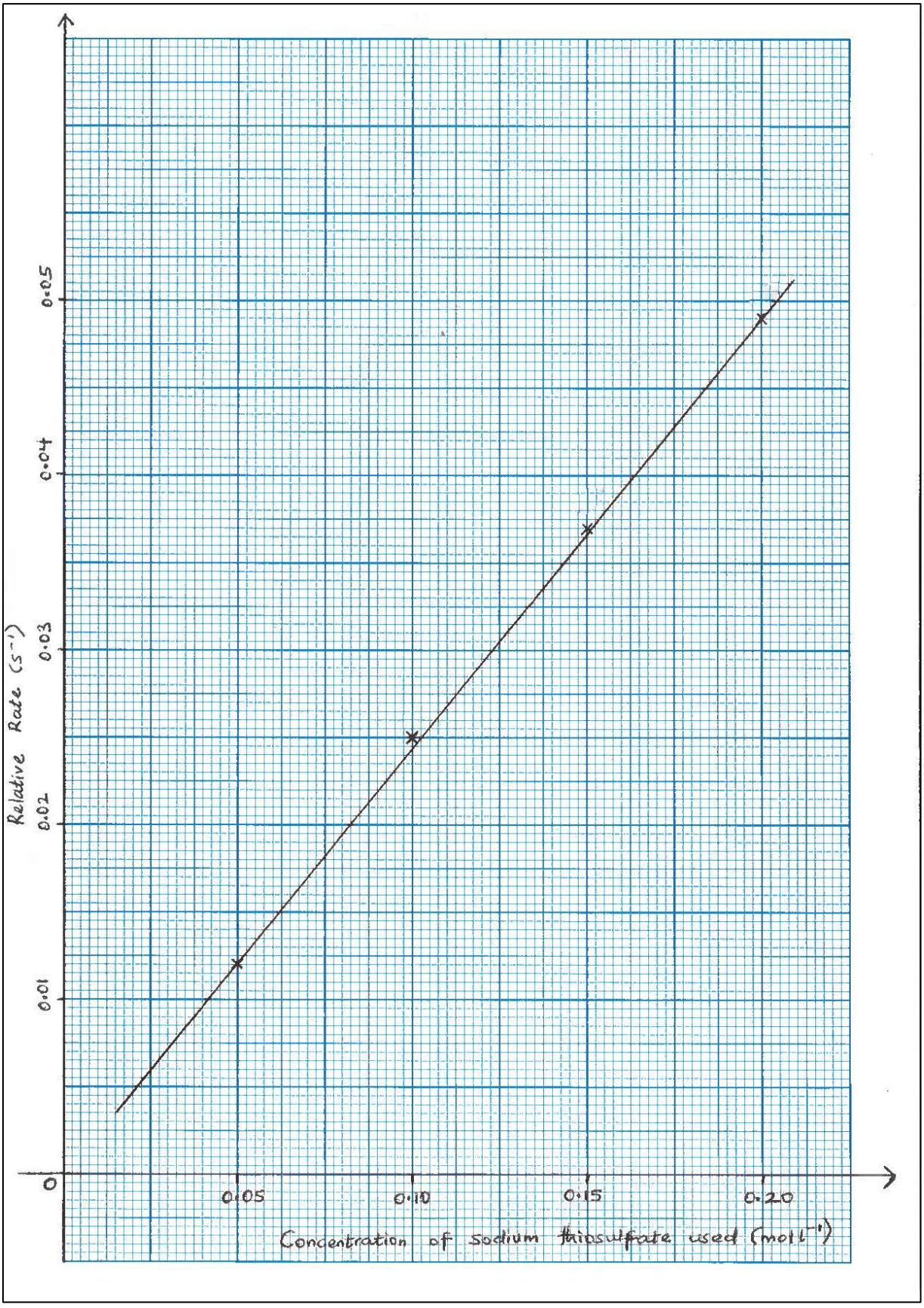
Effect of increasing Concentration in Summary



The reaction here is less concentrated, so particles will not collide as often – the reaction is lower



Here, the reacting particles have a higher chance of colliding therefore, the reaction will go faster.


Relative Rate (s^{-1})
0.05
0.04
0.03
0.02
0.01
0
0.05
0.10
0.15
0.20
Concentration of sodium thiosulfate used ($mol\,l^{-1}$)

Analysis :- My internet source doesn't have the same labellings (and some unit as mine). It also doesn't start from the origin but it can be used to verify that as the concentration of sodium thiosulfate increases, the rate of the reaction increases.

My data differs from my source data — At $0.1\ mol\ l^{-1}$, the rate of the reaction was $0.025\ s^{-1}$ (my data) while at $0.1\ mol\ l^{-1}$ of sodium thiosulfate, the rate of the reaction was $0.02\ s^{-1}$ (the dot from the source data). This means my value was $0.005\ s^{-1}$ more.

Also, at $0.2\ mol\ l^{-1}$, the rate of the reaction was 0.049 (my data) while at $0.2\ mol\ l^{-1}$, the rate of the reaction was approximately $0.039\ s^{-1}$ (source data) — meaning my value was $0.01\ s^{-1}$ more.

Conclusion :- In conclusion, as we increase the concentration of sodium thiosulfate solution, the rate of the concentration — the rate of the reaction is directly proportional to the concentration my source data doesn't show this (not from origin) but it has been proven by my graph and my data.

Evaluation :-

- Due to time factors, I could only carry out three trials. Next time, I could increase the number of trials to eliminate random errors.
- ~~When using my stopwatch~~,
- During the experiment, I started the stopwatch after the hydrochloric acid was added and sometimes while it was being added. I should have done it in one specific way throughout as it would have should better results.
- Errors in my data could have stemmed from wrong measurement of the volume of water required to dilute the sodium thiosulfate solution. Readings should have been taken from the lower meniscus or a burette should have been used as it measures very accurate values unlike the measuring cylinder I used.

References

https://blogs.glowscotland.org.uk/gc/hchemunit/collision-theory/

https://www.atilim.edu.tr/shares/chem/files/CEAC%20104(5).pdf — Internet source Graph.

https://www.flinnsci.com/api/library/Download/78da6c8204aa48a294bd9a51844543ad

https://www.tsfx.edu.au/resources/P_-_Higher_Level_Chemistry_-_Grade_12_-_rate_of_reaction.pdf

Method: 5cm^3 of dilute hydrochloric acid was added to a specific concentration of sodium thiosulfate and a stopwatch was used to calculate the time it took for the 'X' at the bottom of the conical flask to disappear. The same volume was used for different concentrations of sodium thiosulfate - the experiment was repeated, values were recorded and averaged. Although the concentration of sodium thiosulfate solution used was low hazard, safety gloves were worn to prevent staining and to reduce the risk of skin irritation.

$$2HCl_{(aq)} + Na_2S_2O_{3(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(aq)} + S_{(s)} + H_2O_{(l)}.$$

Concentration of sodium thiosulfate used (mol L^{-1})	Time taken for cross to disappear (s) Trial 1	Trial 2	Trial 3	Average time (s)	Relative Rate (s^{-1})
0.05	83.12	81.20	92.11	85.48	0.012
0.10	40.09	40.17	39.76	40.01	0.025
0.15	24.76	28.18	28.93	27.29	0.037
0.20	21.41	18.71	21.54	20.55	0.049

$$\text{Average time} = \frac{83.12 + 81.20 + 92.11}{3} = 85.48$$

the calculation was repeated for other values (Answers were rounded to 2 d.p)

$$\text{Relative rate} = \frac{1}{\text{Average time}} = \frac{1}{85.48} = 0.012$$

the calculation was repeated for all other values (Answers were rounded to 3 d.p).

Internet Source :-