**The effect of temperature on the rate of reaction**

**Also: Rate constant and activation energy**

**Introduction**

In this experiment the effect of temperature on the rate of reaction between sodium thiosulfate and hydrochloric acid is investigated.

The reaction you are going to investigate is

2HCl(aq) + Na2SO3(aq) → S(s) + 2NaCl(aq) + SO2(g) + H2O(l)

**What to do**

1. Write a big cross on a piece of paper.
2. Put 10 cm3 of 0.1 mol dm-3 sodium thiosulfate solution in a small beaker. Measure 10 cm3 of 1 mol dm-3 hydrochloric acid in a small measuring cylinder.
3. Put the beaker over a piece of paper with a big cross drawn on it
4. Add the acid to the sodium thiosulphate and start the clock. Mix the solutions and place the beaker on the cross. Record the initial temperature of the mixture with an electronic thermo-sensor.
5. Look down at the cross from above but **do not inhale the fumes**. When the cross disappears, stop the clock and note the time taken. Record the final temperature of the mixture in the flask.
6. As soon as possible, pour the solution down the sink (in the fume cupboard if possible) and wash away.
7. Now you want to repeat the experiment at four other different temperatures between 15 and 65oC. You can cool down the solutions in the fridge, and you can heat them on a hot plate.

**Safety**

Wear eye protection. Take care not to inhale fumes.

**What to record and calculate**

Record your results in a table like the one below, use LibreCalc or Excel for the data handling.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Initial temperature of the mixture in the beaker ± uncert. /**  **°C** | **Final temperature of the mixture in the beaker ± uncert. /**  **°C** | **Average temperature of the mixture ± uncert. /**  **°C** | **Time taken**  **for the cross in the flask to disappear ± uncert. /s** | **Rate of reaction = 1/time taken**  **/s–1**  **(calculate the uncertainty separately)** |

**A: Dependency of temperature on the rate of reaction**

Present your raw data as you would in a real lab report, including qualitative and quantitative data as well as uncertainties.

Process your data by calculating average temperatures for each determination. Plot temperature – time and temperature – rate of reaction, include and remember everything you should include and remember when you make a graph. Propagate uncertainties, calculate the final uncertainties. Which conclusions can you draw?

Hand in one set of answers per group.

**B: Rate constant and activation energy**

Here you are going to use the equation for the temperature dependency of the rate constant k in the rate reaction rate = *k* [A]m [B]b …

***k = A***

… where A = Arrhenius constant, Ea = activation energy, R = gas constant, T = absolute temperature

1. Use 1/time as the value of rate of reaction for this experiment.
2. Calculate k for each temperature with the concentrations you have used, assume a first order dependency on both reagents (in fact the actual dependency does not matter, as you have the same concentrations in all experiments)
3. Calculate 1/T for each temperature
4. Plot 1/T (x-axis) against ln *k* (y-axis) and read A as well as *Ea* from the graph according to what you have learned.
5. Which value do you get for A, which for EA?
6. If you assume that you can extrapolate the graph a little, then which k and rate of reaction would you get for +75oC and for +5oC?

No regular report is required, but hand/mail in a table with your raw data, your calculations to get the values needed for plotting, the graph and your final calculations as well as A and EA. Use Excel or a similar computer program for the work. Also answer the questions below.

**Student’s evaluation:**

1. How did you contribute to the group’s work?
2. How did the other group members contribute to your task?
3. What have you learned from this task? Remember e.g. the use of the measuring equipment and software, data handling, calculations, theory, e.t.c.)
4. Which grade would you give yourself for the entire job?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **I feel really insecure** | **... a little insecure** | **... quite secure** | **...really secure** | **Motivation** |
| I can set up the measuring equipment |  |  |  |  |  |
| I know how to use the software |  |  |  |  |  |
| I can follow instructions |  |  |  |  |  |
| I can handle the data as needed |  |  |  |  |  |
| I can draw the graphs as needed |  |  |  |  |  |
| I understand and can do the needed calculations to get the answer to the research question |  |  |  |  |  |
| I understand and can do the needed uncertainty propagation calculations |  |  |  |  |  |
| I understand the theory behind this practical work. |  |  |  |  |  |

**Teacher evaluation:**

1. The student’s engagement
2. The quality of the work in the laboratory
3. The data handling, making of graphs, e.t.c.
4. Drawn conclusions
5. Has the student learned something?

The practical work above is according to the IB syllabus, but the teacher can choose to e.g. do only the first part of this if the second part is more than required. Some very interested students may however enjoy the second part as well.