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Universidad del País Vasco
Euskal Herriko Unibertsitatea

11th **Practise:** Reaction between iodide and persulfate ions. Reaction with a catalyst.

Degree in Chemistry 2nd grade,
Experimentation in Physical Chemistry

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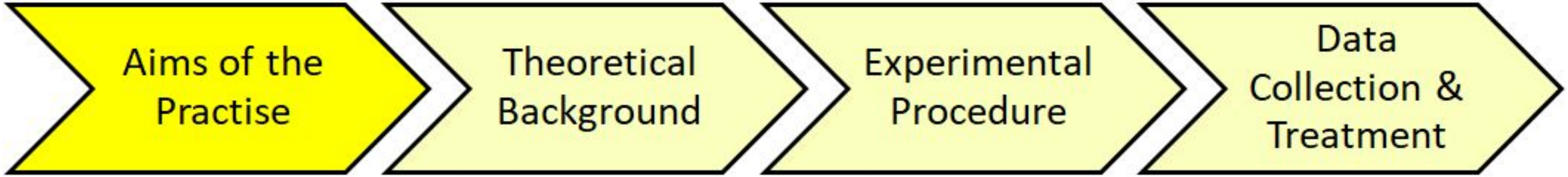
1. Aims of the practise



- Get the reaction order with different reactants.
- Analyse the effect of a catalyst on the reaction’s speed.
- Study the kinetics of the reaction bias the reaction of the generated I^- with $S_2O_3^{2-}$.

2. Theoretical Background

The reaction we will work with: $S_2O_8{}^{2-} + 2I^- \rightarrow 2SO_4{}^{2-} + I_2$

The speed of the reaction can be written in different ways[1]:

$$v = -\frac{d[S_2O_8{}^{2-}]}{dt} = -\frac{1}{2}\frac{d[I^-]}{dt} = \frac{1}{2}\frac{d[SO_4{}^{2-}]}{dt} = \frac{d[I_2]}{dt}$$

For any reaction, we can write the rate equation or rate law: the swiftness in which reactants turn into products:

$$v = k[S_2O_8{}^{2-}]^{\alpha}[I^-]^{\beta}$$

The addition of **α** and ***β*** is called reaction order. Those coefficients do not necessarily have to be the same as the stoichiometric coefficients. k is called reaction rate constant and it is specific for every reaction[2].

[1]Stephen Lower, Professor Emeritus,... Webpage Chemistry LibreTexts
[2]Notes from *Kimika Orokorra II*, *6. Ikasgaia: Zinetika kimikoa*, 2018-2019 school year, Teacher: Marian Iriarte

If we put the reactants in these ratio: $\frac{[K_2S_2O_8]}{[KI]} = \frac{a}{2a}$

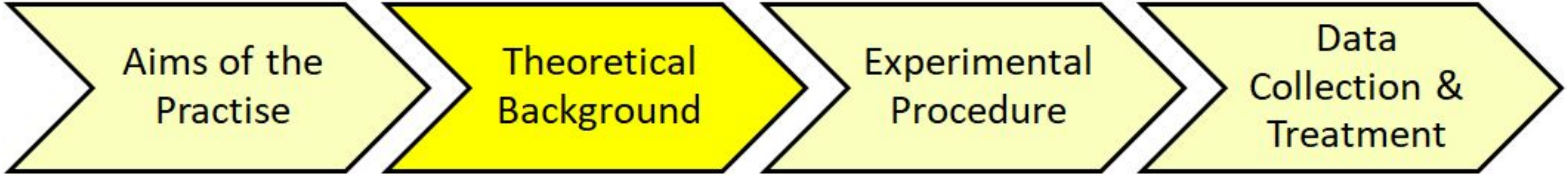
So, whenever the reaction happens, a quantity $\boldsymbol{x}$ of the reactants will be consumed and therefore the same quantity $\boldsymbol{x}$ will be created[3]

Reac.	$S_2O_8^{2-}$	$+ 2I^-$	$\rightarrow 2SO_4^{2-}$	$+ I_2$
Beg.	a	2a	-	-
End	a-$\boldsymbol{x}$	2a-2$\boldsymbol{x}$	2x	x

So, replacing these values into the rate law:

$$\frac{dx}{dt} = k(a-x)^{\alpha}[2(a-x)]^{\beta}$$

[3]Kenneth A. Connors, "Chemical Kinetics: The Study of Reaction Rates in Solution", VHC, Madison (Wisconsin), ISBN: 3-527-21822-3



Consequently, depending on the values of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ the reaction order will be different and so will be the integrated equation.

The objective of this class is to get these coefficients.

Generally, reactions have 4 possible orders[4]:

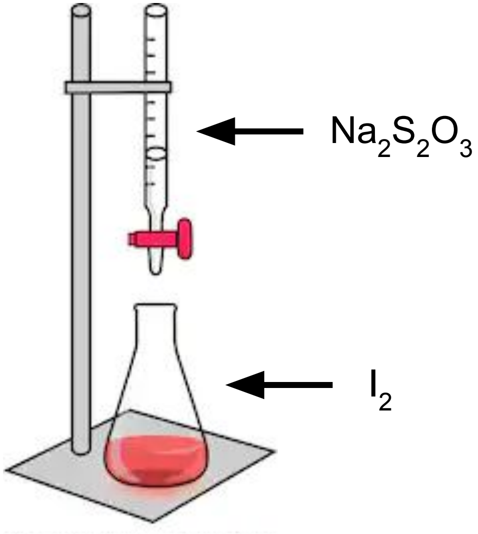
- Order 0 if [X] vs t is linear.
- Order 1 if ln[X] vs t is linear.
- Order 2 if1/[X] vs t is linear.

In order to determine the speed, it is necessary to know the concentration at different times of the reaction. To do so, we will have to take a sample of the reaction and titrate it.

[4]Paul Andersen (Bozeman Science) “*The Rate of Reactions*”, Youtube

The reaction of the titration:

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$



This way we will know the concentration of Iodine in the sample we took.

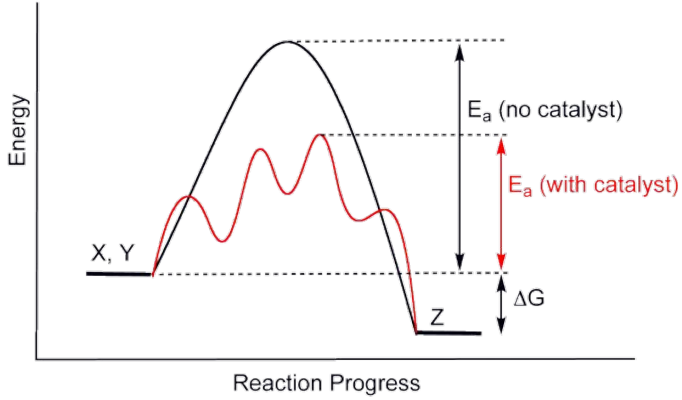
The indicator for this titration will be starch. In contact with iodine, starch turns blue but on its own, I_2 in water solution is yellow-brownish[5].

But for having reliable data, we must stop the reaction. Recollecting these data at different times, we will be able to create the previously seen graphs.

[5]Notes from *Kimika Analitikoa I*, 2019-2020 school year, Teacher: Rosa García

Catalysts are compounds that considerably accelerate reactions. Their interest in industry and in other chemistry fields[2].

Not only do they provoke the reaction to be swifter but they also diminish the necessary energy to start a reaction[6].



[2]Notes from *Kimika Orokorra II*, *6. Ikasgaia: Zinetika kimikoa*, 2018-2019 school year, Teacher: Marian Iriarte
[6]Anne Marie Helmenstine [Catalysis Definition in Chemistry] ThoughtCo.

3. Experimental Procedure

Reactants and material:

- $Na_2S_2O_3$
- KI
- $K_2S_2O_8$
- $FeSO_4$
- Starch
- 50cm^3 Volumetric Flask
- 50cm^3 Pipette
- 250cm^3 Frosted glass Erlenmeyer
- 100cm^3 Erlenmeyer
- Thermostatic bath

Two reactions will be carried out:

<u>1st Reaction:</u>

- Prepare 250 mL 0,01 M $Na_2S_2O_3$, 100 mL 0.05 M KI, 100 mL 0,025 M $K_2S_2O_8$
- Set the thermostatic bath at 40ºC. Heat KI and $K_2S_2O_8$ solutions.
- Put the frosted glass erlenmeyer in the bath and add 50 mL of the $K_2S_2O_8$ solution.
- Pour 50 mL of KI solution and start measuring time and stirring.
- Instantaneously take 10 mL into an Erlenmeyer and put it in the ice to stop the reaction. Add some starch and titrate it.
- Take a sample every 5 minutes and titrate it. You must have 6 samples before finishing.

2nd Reaction:

- Prepare a 50 mL solution containing 0,02 M KI and $2x10^{-3}$ M $FeSO_4$
- Put that solution into the reaction flask and heat it until 40ºC.
- Add 50 mL of 0,01 M $K_2S_2O_8$ diluting the previously made solution. Heat it until 40ºC.
- Pour the $K_2S_2O_8$ into the flask containing $FeSO_4$ and KI. Stir and start measuring the time.
- Instantaneously take 10 mL put it in the ice to stop the reaction, add the starch and titrate it
- Take 5 more samples, one every minute.

Afterwards, repeat the second reaction twice. One time with $FeSO_4$ $4x10^{-3}$ M and the second time with $FeSO_4$ $6x10^{-3}$ M

Additionally, each group will make a reaction with a concentration of $FeSO_4$ they want.

4. Data Collection and Treatment

During the experiment, we will have to measure both time and $[I_2]$ to later construct a graph and get the reaction rate constant.

We can deduce the 2nd order rate law. Afterwards we will have to transform this equation to make it depend on the volume of $Na_2S_2O_3$ consumed for the titration.

We will now build the graph to obtain the speed constant for the first reaction.

With the data of other groups for different catalyst concentrations calculate the catalytic constant at 40ºC and check that the kinetic order for the catalyst is 1 eman ta zabal zazu

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