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Iodine clock experiment

The goal of this experiment is to determine the rate law for a chemical reaction using the method of initial rates

Only those reagents that participate in the RLS (normally) affect the rate of reaction.

In the method of initial rates, the concentrations of reagents in each trial are individually varied to see what effect changing concentration has on rate.

$$3I^{-}_{(aq)} + S_2O_8^{-2}{}_{(aq)} \longrightarrow I_3^{-}{}_{(aq)} + 2SO_4^{-2}{}_{(aq)}$$

This is the reaction being studied in this experiment.

There is no connection between an overall stoichiometric equation and a rate law, since the stoichiometric equation does not indicate how many steps occur or which step, if any, is the rate-limiting step.

In this reaction, since only the stoichiometric equation is known, that is why an experiment must be performed to determine the rate law.

In order to measure the rate of a reaction, there must be a measurable change in some concentration. Ideally, to equally compare each trial, The same amount of concentration change should occur for each rxn.

By analogy to a race, each trial will "run" the same distance, so the rate can simply be determined by how long it takes to reach the "finish line".

Chemical Reactions

I) $3KI_{(aq)} + (NH_4)_2S_2O_{8\,(aq)} \rightarrow I_3^-{}_{(aq)} + 2SO_4^{-2}{}_{(aq)}$

- This equation contains the RLS step being studied in this experiment

II) $I_3^-{}_{(aq)} + 2Na_2S_2O_{3\,(aq)} \rightarrow 3I^-{}_{(aq)} + S_4O_6^{-2}{}_{(aq)}$

- This reaction controls the extent of reaction ("distance, finish line")

III) $I_3^-{}_{(aq)} + \text{starch} \rightleftharpoons \text{complex}$

- This reaction turns the mixture an easily visible dark color.

The purpose of $S_2O_3^{-2}$ is to consume the same amount of I_3^- in each trial, as I_3^- is formed, the I_3^- can be destroyed even if it forms a complex with starch because formation of the complex is reversible.

No color change will occur until all of the thiosulfate is consumed. The color change indicates the end of the trial.

Reaction	Test Tube	0.2 % Starch	0.012 M $Na_2S_2O_3$	0.20 M KI	0.20 M KNO_3
1	1A	0.10	0.20	0.80	0.00
2	2A	0.10	0.20	0.40	0.40
3	3A	0.10	0.20	0.20	0.60
4	4A	0.10	0.20	0.10	0.70

Reaction	Test Tube	0.20 M $(NH)_2S_2O_8$	0.20 M $(NH_4)_2SO_4$
1	1B	0.40	0.40
2	2B	0.40	0.40
3	3B	0.40	0.40
4	4B	0.40	0.40

volumes, not concentrations
→ same total volume

- reagents related to RLS
- controls extent of rxn
- unreactive reagents that are present to maintain the same total solution volume and the same overall ion concentration.

- In kinetics experiments, it is critical to eliminate as many variables as possible.

All of the trials react to the same extent, which is controlled by the amount of $S_2O_3^{-2}$ present, therefore it makes sense that thiosulfate should be the basis of any stoichiometric calculations.

$$rate = -\frac{\Delta[S_2O_3^{-2}]}{\Delta t}$$

This reagent is not involved in the rxn with the RLS

due to $S_2O_3^{-2}$ being consumed

$$1\,I_3^-(aq) + 2\,S_2O_3^{-2}(aq) \rightarrow 3I^- + S_4O_6^{-2}$$

Because $S_2O_3^{-2}$ controls the rxn extent, it can be used to determine $\Delta[I_3^-]$, which is involved in the RLS

$$rate = \frac{\Delta[I_3^-]}{\Delta t} = -\frac{1}{2}\frac{\Delta[S_2O_3^{-2}]}{\Delta t}$$

This quantity is the same in all trials

$$rate = C/\Delta t$$