

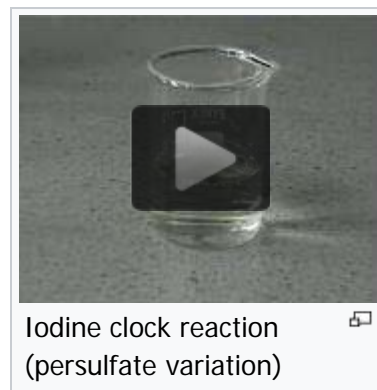
Iodine clock reaction

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The **iodine clock reaction** is a classical [chemical clock](#) demonstration experiment to display [chemical kinetics](#) in action; it was discovered by [Hans Heinrich Landolt](#) in 1886.^[1] The iodine clock reaction exists in several variations, which each involve [iodine](#) species ([iodide](#) ion, free iodine, or [iodate](#) ion) and [redox](#) reagents in the presence of [starch](#). Two colourless solutions are mixed and at first there is no visible reaction. After a short time delay, the liquid suddenly turns to a shade of dark blue due to the formation of a [triiodide-starch complex](#). In some variations, the solution will repeatedly cycle from colorless to blue and back to colorless, until the reagents are depleted.

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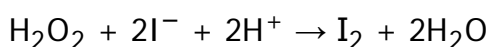
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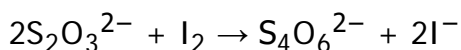
Hydrogen peroxide variation [edit]

This reaction starts from a solution of [hydrogen peroxide](#) with [sulfuric acid](#). To this is added a solution containing [potassium iodide](#), [sodium thiosulfate](#), and [starch](#). There are two reactions occurring in the solution.

In the first, slow reaction, iodine is produced:



In the second, fast reaction, iodine is reconverted to 2 iodide ions by the thiosulfate:



After some time the solution always changes color to a very dark blue, almost black.

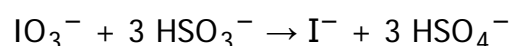
When the solutions are mixed, the second reaction causes the [triiodide](#) ion to be [consumed much faster than it is generated](#), and only a small amount of triiodide is present in the [dynamic equilibrium](#). Once the thiosulfate ion has been exhausted, this reaction stops and the blue colour caused by the triiodide – starch complex appears.

Anything that accelerates the first reaction will shorten the time until the solution changes color. Decreasing the pH (increasing H^+ concentration), or increasing the concentration of iodide or hydrogen peroxide will shorten the time. Adding more thiosulfate will have the opposite effect; it will take longer for the blue colour to appear.

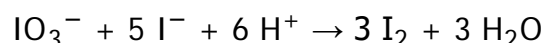
Iodate variation [edit]

An alternative protocol uses a solution of [iodate](#) ion (for instance potassium iodate) to which an acidified solution (again with [sulfuric acid](#)) of [sodium bisulfite](#) is added.

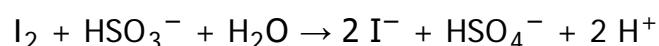
In this protocol, [iodide](#) ion is generated by the following slow reaction between the iodate and bisulfite:



This is the rate determining step. The iodate in excess will oxidize the iodide generated above to form iodine:



However, the iodine is reduced immediately back to iodide by the bisulfite:

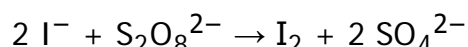


When the bisulfite is fully consumed, the iodine will survive (i.e., no reduction by the bisulfite) to form the dark blue complex with starch.

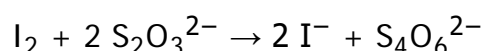
Persulfate variation [\[edit\]](#)

This clock reaction uses [sodium](#), [potassium](#) or [ammonium persulfate](#) to [oxidize iodide](#) ions to [iodine](#). [Sodium thiosulfate](#) is used to reduce iodine back to iodide before the iodine can complex with the [starch](#) to form the characteristic blue-black color.

Iodine is generated:



And is then removed:



Once all the thiosulfate is consumed the iodine may form a complex with the starch. Potassium persulfate is less soluble (cfr. [Salters website](#)) while ammonium persulfate has a higher solubility and is used instead in the reaction described in examples from [Oxford University](#).^{[\[2\]](#)}

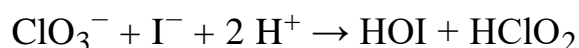
Chlorate variation [\[edit\]](#)

An experimental iodine clock sequence has also been established for a system consisting of [iodine](#) [potassium-iodide](#), [sodium chlorate](#) and [perchloric acid](#) that takes place through the following reactions.^{[\[3\]](#)}

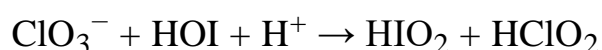
[Triiodide](#) is present in equilibrium with [iodide](#) anion and molecular [iodine](#):



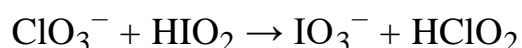
Chlorate ion oxidizes iodide ion to [hypoiodous acid](#) and [chlorous acid](#) in the slow and [rate-determining step](#):



Chlorate consumption is accelerated by reaction of hypoiodous acid to [iodous acid](#) and more chlorous acid:



More [autocatalysis](#) when newly generated iodous acid also converts chlorate in the fastest reaction step:



In this clock the [induction period](#) is the time it takes for [autocatalytic](#) process to start after which the concentration of free [iodine](#) falls rapidly as observed by [UV/VIS spectroscopy](#).

See also [edit]

- [Clock reaction](#)
- [Old Nassau reaction](#)

References [edit]

- ↑ See:
 - Landolt, H. (1886). "Ueber die Zeitdauer der Reaction zwischen Jodsäure und schwefliger Säure" [On the duration of the reaction between iodic acid and sulfurous acid]. *Berichte der Deutschen Chemischen Gesellschaft* (in German). **19**: 1317–1365.
 - Landolt, H. (1887). "Ueber die Zeitdauer der Reaction zwischen Jodsäure und schwefliger Säure [Part 2]" [On the duration of the reaction between iodic acid and sulfurous acid]. *Berichte der Deutschen Chemischen Gesellschaft* (in German). **20**: 745–760. doi:10.1002/cber.188702001173 .
- ↑ Hugh Cartwright (2006). "Kinetics of the Persulfate-iodide Clock Reaction" (PDF). *2nd/3rd Year Physical Chemistry Practical Course*. Oxford University. Retrieved 25 March 2018.
- ↑ André P. Oliveira and Roberto B. Faria (2005). "The chlorate-iodine clock reaction". *J. Am. Chem. Soc.* **127** (51): 18022–18023. doi:10.1021/ja0570537 . PMID 16366551 .

External links [edit]

- [Hydrogen peroxide variation](#)
- [Sodium bisulfite variation with a high-speed camera](#)

Categories: [Chemical kinetics](#) | [Chemical reactions](#) | [Iodine](#) | [Thiosulfates](#)