# TY CHEMISTRY: Iodine clock reaction

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**Iodine Clock Reaction:**

A solution of hydrogen peroxide is mixed with one containing potassium iodide, starch and sodium thiosulfate. After a few seconds the colourless mixture suddenly turns dark blue. This is one of a number of reactions loosely called the iodine clock. It can be used as an introduction to experiments on rates / kinetics.

**Teaching notes:**

Visual tips: a white background will help so that the impact of the sudden and spectacular colour change is not lost. Scaling up the volumes of solution that are mixed may help in a large room.

There is no warning of when the blue colour is about to appear. It may help understanding if the students are already familiar with the reactions of starch and iodine, and iodine and sodium thiosulfate, so it may be worth demonstrating these beforehand.

The basic reaction is:

$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$

[For more advanced discussions or investigations - this reaction is the rate determining step and is first order with respect to both $H_2O_2$ and $I^-$.]

As soon as the iodine is formed, it reacts with the thiosulfate to form tetrathionate ions and recycles the iodide ions by the fast reaction:

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

As soon as all the thiosulfate is used up, free iodine (or, strictly, $I_3^-$ ions) remains in solution and reacts with the starch to form the familiar blue-black complex.

The time for the blue colour to appear can be adjusted by varying the amount of thiosulfate in solution X so a 'clock' of any desired time interval can be produced.
If the demonstration is being done for entertainment, the imaginative teacher will be able to think up some suitable patter.

**Apparatus and chemicals:**

- Eye protection
- Balance (1 or 2 d.p.)
- Volumetric flasks (1 litre),
- Beakers (100 $cm^3$), 12
- Beaker (250 $cm^3$) 12
- Beaker (2 $dm^3$)
- Boiling tubes, 12
- Boiling tube rack
- Measuring cylinder (50 $cm^3$)
- Measuring cylinders (100 $cm^3$), 2
- Stirring rod or magnetic stirrer and follower (optional)
- Stopclock/timer,

**Chemicals:**

0.2 g soluble starch

1M sulfuric acid (Irritant), 150 $cm^3$ 

Potassium iodide (KI), 6.0 g. (Low hazard)

Sodium thiosulfate-5-water ($Na_2S_2O_3.5H2O$), 7.5 g (Low hazard ) **:** Irritant to eyes

20 volume hydrogen peroxide solution ($H_2O_2(aq)$), 250 $cm^3$ (Irritant) ) 

Deionised/distilled water, 1000 $cm^3$.

**Technical notes:**
20 volume hydrogen peroxide is Irritant.
1M sulfuric acid is Corrosive.

**1**. Solution X and the starch solution should be made up before the demonstration. The solutions will keep overnight, but best results are obtained if the solutions are made up on the day.

**2.** The starch solution needs to be fresh.

**Procedure:**
HEALTH & SAFETY: Wear eye protection

***Solution X is made up as follows:***
a Dissolve 6.0 g of potassium iodide in approximately 800 $cm^3$ of distilled water.

b To the potassium iodide solution add 7.5 g of sodium thiosulfate and dissolve.

c Transfer the solution to a 1 $dm^3$ volumetric flask and make up the solution to 1 $dm^3$ with distilled water. Ensure the solution is well mixed.

***Starch Solution is made up as follows:***
a Make a paste of 0.2 g of soluble starch with a few drops of water in a 250 $cm^3$beaker. Pour onto this approximately 100 $cm^3$ of boiling water and stir.
Both solutions are colourless although solution X will be slightly cloudy on storage.

**Dividing up the Groups.**
Depending on the size of the class, groups are allocated a number of beakers labelled 1 to 12. So, if you have a class of 24, each group of two prepares one hour of the clock. If you have 18 then 6 groups of three prepare two hours on the clock, ("Hour Cards" in separate file)

Twelve 250 $cm^3$ beakers each labelled 1 to 12 are prepared containing

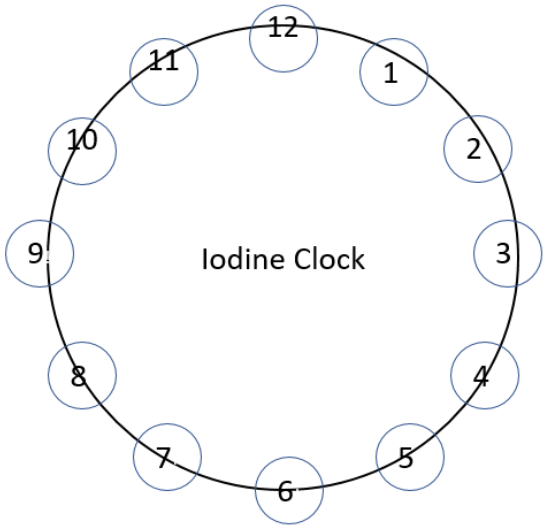
20 $cm^3$ of solution "X"

10 $cm^3$ of 1M sulphuric acid

2 $cm^3$of the starch solution.

| Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soln. X | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| $H_2SO_4$ | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Starch | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Stand the twelve 250 $cm^3$ beakers on their appropriate hour on a prepared laminated poster of a circular clock.




Each group now prepares the corresponding 100 $cm^3$ beakers containing 30 $cm^3$ solutions of hydrogen peroxide and water. Label these beakers 1 to 12 also.

When ready each beaker should contain 30 $cm^3$ of solution.

| Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_2O_2$ | 30 | 27 | 25 | 23 | 20 | 18 | 15 | 13 | 10 | 8 | 5 | 3 |
| water | 0 | 3 | 5 | 7 | 10 | 12 | 15 | 17 | 20 | 22 | 25 | 27 |

Leave the solutions to settle for about 5 minutes. Discuss with the students the effect of concentration on the rate of a reaction in terms of collisions.

**Demonstration**
HEALTH & SAFETY: Wear eye protection

- Students now position themselves at their appropriate station around the clock.
- At a given signal all students add the contents of the 100 $cm^3$ beakers to the corresponding 250 $cm^3$ beakers and begin the stop clocks.
- Each beaker should show the formation of iodine by changing to a blue/black colour going clockwise and slowing down at about 9 o'clock
- Students should record the time taken for the change in colour (colourless to blue/black) for their own beaker.

**Results:**
The time taken for each beaker is recorded and each group makes their own record of the time taken for each beaker to change colour.
The student now draws a graph of volume of $H_2O_2$ used versus 1/t.

**Extension Work:**
Students can now be asked to choose a volume of $H_2O_2$ not used so far and predict the time they would expect the blue colour to form. They can then carry out the procedure and verify their prediction.

- The amount of Potassium Iodide **or** the amount of Sodium Thiosulphate used in solution X may also be varied.
- Choose a fixed concentration (vol) of $H_2O_2$ and same weight of KI when varying Thiosulphate.
- Choose a fixed concentration (vol) of $H_2O_2$ and same weight of $Na_2S_2O_3$ when varying Potassium Iodide.