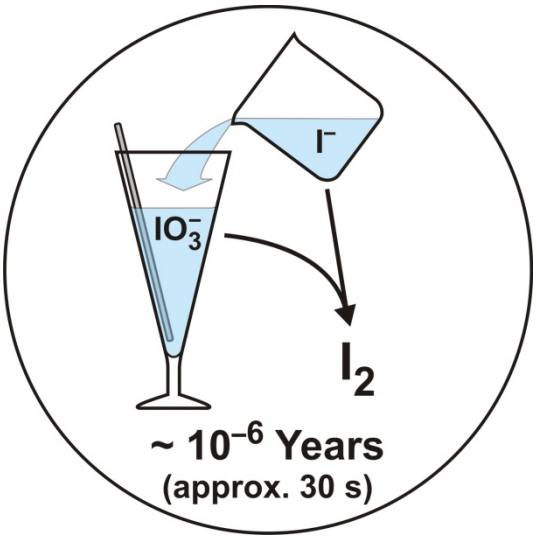
Reaction of Iodide with Iodate



Equipment:

goblet (conical glass cup)
glass rod
beaker (150 mL)

Chemicals:

potassium iodate solution (0.1 kmol m^{-3})
sodium acetate solution (1 kmol m^{-3})
acetic acid (1 kmol m^{-3})
sodium sulfite
sulfuric acid (1 kmol m^{-3})
potassium iodide solution (1 kmol m^{-3})
starch solution (w = 2 %)
demineralized water

Safety:

potassium iodate (KIO_3):

H272, H302, H319
P221, P280, P305+351+338, P313

acetic acid (CH_3COOH) (concentrated):

H226, H314
P210, P280, P301+330+331, P303+361+353, P305+351+338, P310

sulfuric acid (H_2SO_4) (1 kmol m^{-3}):

H290, H315, H319
P280, P302+352, P305+351+338, P337+313

potassium iodide (KI):

H372
P270

Since the substances potassium iodate, diluted sulfuric acid and especially concentrated acetic acid can cause severe eye irritation and damage, and the latter two can also cause skin irritation and even burns, suitable protective gloves and safety goggles have to be worn when preparing the solutions. In particular, the handling of concentrated acetic acid should be carried out in a fume hood.

Procedure:

Preparation: Before starting the experiment, a solution with a sodium sulfite concentration of 0.03 kmol m^{-3} is prepared. For this purpose, 0.38 g of sodium sulfite are weighed out, 3 mL of the diluted sulfuric acid (1 kmol m^{-3}) are added and then demineralized water is

used to complete the volume to 100 mL. To prepare the starch solution, 0.5 g of starch are dissolved in 250 mL of demineralized water at boiling temperature and the solution is then allowed to cool down.
Procedure: 10 mL of the potassium iodate solution, 10 mL of the sodium acetate solution, 20 mL of the diluted acetic acid and 160 mL of demineralized water are successively poured into the goblet. 10 mL of the potassium iodide solution are mixed with 1 mL of the starch solution and 10 mL of the sodium sulfite solution in the beaker. Subsequently, the solution in the beaker is rapidly added to the solution in the goblet and the whole liquid is shortly, but carefully stirred.

Observation:

After a period of about 30 seconds, the solution suddenly turns blue-black.

Variant:

The reaction should be allowed to run in parallel without the addition of sodium sulfite and starch in order to show the slow formation of iodine, which can be recognized by its brown color.

Explanation:

In acidic solution, the iodate ions react with the iodide ions in a slow reaction to form elemental iodine:

$$IO_3^-|w + 5\ I^-|w + 6\ H^+|w \rightarrow 3\ I_2|w + 3\ H_2O|l.$$

This is a comproportionation reaction (also called a synproportionation reaction), i.e. a reaction in which an element in a higher oxidation state reacts with the same element in a lower oxidation state to give the element in an intermediate oxidation state. In the concrete case, elemental iodine with the oxidation number 0 is formed from the iodate ions with the oxidation number +5 and the iodide ions with the oxidation number –1.
However, the resulting iodine is immediately reduced to iodide ions by the sulfite ions in a faster reaction:

$$I_2|w + SO_3^-|w + H_2O|l \rightarrow 5\ I^-|w + SO_4^-|w + 3\ H^+|w.$$

Only when the sulfite ions in the solution are fully consumed, a detectable amount of iodine can be formed, leading to the appearance of the characteristic blue-black inclusion compound with soluble starch (amylose). Amylose has a helical structure with a central channel-like cavity which permits polyiodide chains to be incorporated.

Disposal:

Sodium thiosulfate or another reducing agent is added (in small portions) to the solution until the blue color has disappeared due to reduction of the iodine to iodide ions. The solution contains only such low concentrations of the respective substances that it can subsequently be disposed of in the wastewater.