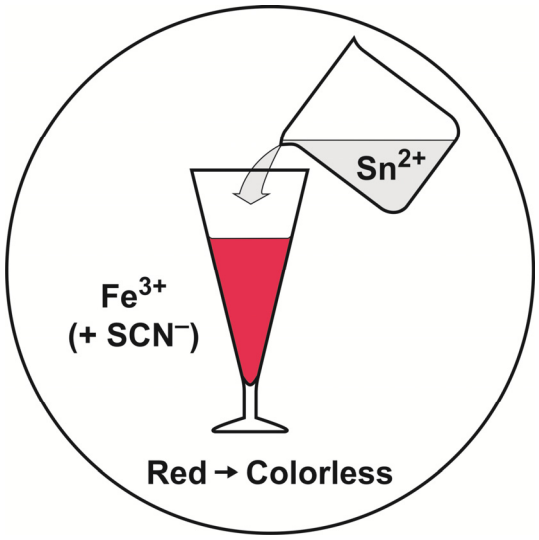
Reduction of Fe^{3+} ions by Sn^{2+} ions



Equipment:

goblet (conical glass cup)
glass beaker (50 mL)
graduated cylinder
dropper
glass rod

Chemicals:

iron (III) nitrate solution (ca. 0.2 kmol m^{-3})
(e.g. 20 g of $Fe(NO_3)_3\,9H_2O$ dissolved in 250 mL of water)
acidified tin(II) chloride solution (ca. 1 kmol m^{-3})
(e.g. 5 g of $SnCl_2\,2H_2O$ dissolved in 20 mL of Wasser and 1 mL of concentrated hydrochloric acid)
ammonium thiocyanate solution (ca. 1 kmol m^{-3})
(e.g. 7.6 g of NH_4SCN dissolved in 100 mL Wasser)
deionized water

Safety:

iron(III) nitrate nonahydrate ($Fe(NO_3)_3\,9H_2O$):

H272, H315, H319
P302 + P352, P305 + P351 + P338

tin(II) chloride dihydrate ($SnCl_2\,2H_2O$):

H302, H315, H317, H319, H335
P280, P302 + P352, P305 + P351 + P338

ammonium thiocyanate (NH_4SCN):

H332, H312, H302, H412
P273, P302 + P352

It is required to wear safety glasses and protective gloves; if possible, the experiment should be carried out in a fume hood.

Procedure:

Preparation: 5 mL of the iron(III) nitrate solution are poured into the goblet and made up to 150 mL with deionized water. 20 mL of the tin (II) chloride solution are provided in the beaker.
Procedure: About 10 drops of ammonium thiocyanate solution are added to the goblet and the solution is stirred. Subsequently, the blood-red solution is mixed with the tin(II) chloride solution and stirred again.

Observation:

The strong red color disappears a few minutes after Sn^{2+} is added.

Explanation:

The iron(III) cations react with the thiocyanate anions to form deep red colored iron(III) thiocyanate complexes. If a tin(II) solution is added to the solution containing iron(III), according to the conversion formula

$$2\ Fe^{3+}|w + Sn^{2+}|w \rightarrow 2\ Fe^{2+}|w + Sn^{4+}|w$$

Fe^{3+} will be reduced to Fe^{2+}, while Sn^{2+} will be oxidized to Sn^{4+}, because according to the levels of the electron potentials [$\mu_e^{\ominus}(Sn^{2+}/Sn^{4+}) = -14$ kG > $\mu_e^{\ominus}(Fe^{2+}/Fe^{3+}) = -74$ kG], the redox pair Sn^{2+}/Sn^{4+} is more strongly reducing than the redox pair Fe^{2+}/Fe^{3+}. Therefore, the deep red color of the solution caused by the ferric thiocyanate complexes gradually disappears as the reaction progresses.

Disposal:

The solution is poured in a special jar for heavy metal waste disposal.