A transient red colour: the aqueous chemistry between iron(III) ions and sulphur oxoanions

Time

1–1.5 h.

Curriculum links

Sulphur chemistry – much of this can be looked up in text books by students.

Bonding in sulphur oxoanions. Redox reactions.

Group size

2– 4.

Materials and equipment

Materials per group

- 20 cm^3 of 1 mol dm^{-3} solutions of each of:

(Hazards are given for the solids – where no mention is made of the solution, the classification is the same)

sodium sulphide (Na_2S) (corrosive to skin and eyes, harmful if swallowed, toxic in contact with skin, Contact with acids liberates toxic gas. Toxic to aquatic organisms)

sodium thiocyanate (NaSCN) (Harmful if swallowed, inhaled or in contact with the skin; Contact with acids liberates toxic gas. (1 mol dm^{-3} solution is of low hazard)

sodium sulphate (Na_2SO_4) No significant hazard

sodium sulphite (Na_2SO_3) (harmful if swallowed, causes serious eye damage, contact with acids liberates toxic gas)

sodium thiosulphate ($Na_2S_2O_3$) No significant hazard.

sodium metabisulphite ($Na_2S_2O_5$) (harmful if swallowed, causes serious eye damage, contact with acids liberates toxic gas) (1 mol dm^{-3} solution causes serious eye damage and in contact with acids liberates toxic gas)

sodium dithionite ($Na_2S_2O_4$) Self-heating solid – may catch fire. Harmful if swallowed. (1 mol dm^{-3} solution is of low hazard)

sodium pyrosulphate ($Na_2S_2O_7$) No significant hazard.

sodium tetrathionate ($Na_2S_2O_6$) Skin, eye and respiratory irritant.

sodium dithionate ($Na_2S_4O_6$) No significant hazard.

sodium persulphate ($Na_2S_2O_8$). Skin/respiratory sensitiser, Skin/eye/respiratory irritant, harmful if swallowed. (1 mol dm^{-3} solution is a skin/respiratory sensitiser and a skin/eye irritant)

Iron(III) chloride ($FeCl_3$) Corrosive to skin/eyes, harmful if swallowed, Hazardous to the aquatic environment.

Equipment per group

- test-tubes, test-tube racks
- spatulas
- dropping pipettes
- aqueous 0.5% (w/v) iron(III) chloride solution
- safety glasses.

Safety

Eye protection must be worn.

Disposal: The test tube samples can be washed to waste with plenty of running water. Larger quantities of most should be kept for disposal.

Risk assessment

A risk assessment must be carried out for this activity.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [http://science.cleapss.org.uk/] in England, Wales and Northern Ireland and, in Scotland, SSERC [https://www.sserc.org.uk/].

Commentary

Students should be encouraged to draw out the structures of the sulphur-based anions

and consider how the anions might interact with the Fe^{3+} ion.

If 3 cm^3 of the sulphur anion solution is mixed with the same volume of iron(III) solution then the solutions in bold type will give a transient red colour:

sodium sulphide (Na_2S)

sodium thiocyanate (NaSCN)

sodium sulphate (Na_2SO_4)

sodium sulphite (Na_2SO_3)

sodium thiosulphate ($Na_2S_2O_3$)

sodium metabisulphite ($Na_2S_2O_5$)

sodium dithionite ($Na_2S_2O_4$)

sodium pyrosulphate ($Na_2S_2O_7$)

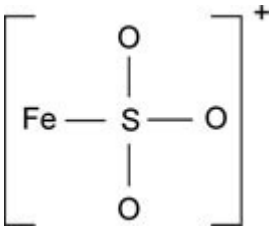
sodium tetrathionate ($Na_2S_2O_6$)

sodium dithionate ($Na_2S_4O_6$)

sodium persulphate ($Na_2S_2O_8$).

Possible answer

The correct answer is not known. A connection between the observations[1] is that those sulphur ions that can bond to iron through sulphur give the red colour – *eg*



This is a possible intermediate in the redox reaction.

Reference

1. For further background see N. V. Reed, *School Sci. Rev.*, 1986, 768.

Credits

Health & safety checked May 2018

Page last updated October 2018