Measuring an equilibrium constant

Topic

Scientific methodology, reversible reactions.

Timing

30 min.

Description

This experiment is a microscale version of experiment 11.2 in the Nuffield A-Level Chemistry course (3rd edn. 1994). It uses the microscale titration apparatus (see 'Apparatus and techniques for microscale chemistry' handout) to measure the equilibrium constant of the redox reaction between silver(I) and iron(II):

$$Ag^{+}(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

One of the main advantages of this microscale version is that it uses less silver solution than the existing method and is therefore more economical.

Apparatus (per group)

- Microscale titration apparatus, see 'Apparatus and techniques for microscale chemistry' handout.- One stoppered flask (*eg* 5–10 cm^3)
- Two 2 cm^3 pipettes
- One 10 cm^3 beaker.

Chemicals (per group)

- Iron(II) sulphate solution 0.10 mol dm^{-3}

Dissolve 2.780 g of Analar grade $FeSO_4.7H_2O$ in 50 cm^3 of 0.5 M sulphuric acid and make up to 100 cm^3 with deionised water in a volumetric flask.

- Silver nitrate solution 0.10 mol dm^{-3}

Dissolve 0.849 g of $AgNO_3$ in deionised water and make up to 50 cm^3 in a volumetric flask. Store in the dark if this solution is not to be used immediately (it will be useable for several days). This is sufficient solution for 20–25 pairs of students to do the experiment. The amounts may be scaled down if appropriate.

- Potassium thiocyanate solution 0.020 mol dm^{-3}

Dissolve 0.194 g of potassium thiocyanate in deionised water and make up to 100 cm^3 in a volumetric flask.

Observations

A white precipitate of silver thiocyanate forms until the end-point when a permanent red colour due to $Fe(SCN)^{2+}$ is seen.

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Results

The Nuffield teachers' guide does not give a value for K_c and merely says that the results are rather variable, due in part to the difficulty of maintaining a pure solution of iron(II) sulphate.

The Nuffield textbook states that the silver nitrate/iron(II) sulphate mixture should be allowed to stand overnight for equilibrium to be established. These conditions have been adhered to for this microscale titration although it is possible that less time is required (this could form the basis of an interesting student project, *ie* establishing the time taken to reach equilibrium). Nevertheless, students should set up the stoppered flask at the end of one lesson and do the titration at the next.

Reference

Nuffield advanced science – chemistry, students' book and teachers' guide. 3rd edn. Harlow: Longmans, 1994.

Health & Safety

Students must wear eye protection.

Iron(II) sulfate, 0.1 mol dm^{-3}, $FeSO_4.7H_2O$ (aq) and Potassium thiocyanate solution 0.020 mol dm^{-3} are of low hazard.

Sulfuric acid, 0.5 mol dm^{-3} H_2SO_4(aq) is of low hazard (if accurately made up. It becomes irritant at 0.51 mol dm^{-3})

Silver nitrate solution 0.10 mol dm^{-3} is IRRITANT.

Credits

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Health & safety checked May 2018

Page last updated August 2018

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