

Equilibrium constants and shifting equilibria

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

This lab uses a colorimeter to find the equilibrium constant of the iron(III) thiocyanate reaction. You will turn absorbance readings into concentrations, build ICE tables for four mixtures, compare the four values of K_c and judge the effect of the assumption made for the standard.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R2.3

Aim

Find the equilibrium constant K_c for $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons [\text{Fe}(\text{SCN})]^{2+}(\text{aq})$ by measuring the absorbance of the red complex in four equilibrium mixtures.

Equipment

- 0.0200 mol/dm³ iron(III) nitrate in 0.10 mol/dm³ nitric acid, 0.200 mol/dm³ iron(III) nitrate in 0.10 mol/dm³ nitric acid, 0.00200 mol/dm³ potassium thiocyanate, 0.10 mol/dm³ nitric acid
- colorimeter with a blue-green filter and matched cuvettes
- two 10 cm³ graduated pipettes or syringes, five test tubes, labels, safety goggles and gloves

Safety

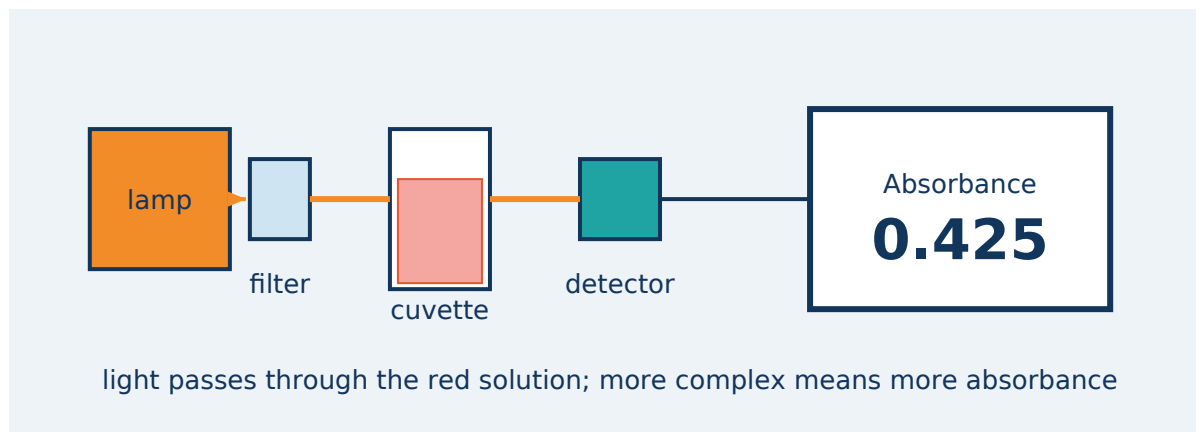
Safety

Wear safety goggles and gloves. Dilute nitric acid and iron(III) nitrate are irritants, and potassium thiocyanate is harmful if swallowed or mixed with strong acid. Wash spills from skin at once with plenty of water. Dispose of all solutions as directed by your teacher.

Method

1. Prepare the standard tube: 5.0 cm³ of 0.200 mol/dm³ iron(III) nitrate + 1.0 cm³ of thiocyanate + 4.0 cm³ of nitric acid. Almost all of the thiocyanate becomes the red complex.
2. Prepare four test tubes: 5.0, 4.0, 3.0 and 2.0 cm³ of 0.0200 mol/dm³ iron(III) nitrate, each with 2.0 cm³ of thiocyanate, and add nitric acid to make 10.0 cm³.
3. Zero the colorimeter with a tube of nitric acid. Measure the absorbance of the standard and of each mixture, at the same room temperature.

4. Record the absorbances. They are proportional to the concentration of the red complex.



Colorimeter used to measure the absorbance of each solution.

Results

Tube	Volume 0.0200 mol/dm ³ Fe ³⁺ (cm ³)	Absorbance
Standard	(5.0 cm ³ of 0.200 mol/dm ³)	0.380
1	5.0	0.470
2	4.0	0.425
3	3.0	0.366
4	2.0	0.286

Analysis questions

Question 1 Complex concentration

The standard tube has $[\text{Fe}(\text{SCN})^{2+}] = 2.00 \times 10^{-4} \text{ mol/dm}^3$ (all thiocyanate converted). Use absorbance proportional to concentration to calculate $[\text{Fe}(\text{SCN})^{2+}]$ in tubes 1 to 4.

Question 2 Initial concentrations

Calculate the initial $[\text{Fe}^{3+}]$ and $[\text{SCN}^-]$ in each tube after mixing to 10.0 cm³.

Question 3 Equilibrium concentrations

Write an ICE table and calculate the equilibrium $[\text{Fe}^{3+}]$ and $[\text{SCN}^-]$ for each tube.

Question 4 Calculating Kc

Write the Kc expression and calculate Kc for each tube.

Question 5 Mean and consistency

Calculate the mean K_c and comment on the consistency of the four values.

Question 6 Assumption in the standard

At $[\text{Fe}^{3+}] = 0.100 \text{ mol/dm}^3$ in the standard tube, about 93 % of the thiocyanate is converted (not 100 %) when K_c is near 140. Explain the effect on the calculated K_c .

Question 7 Prediction with silver ions

A few drops of silver nitrate are added to tube 2 ($\text{Ag}^+ + \text{SCN}^- \rightarrow \text{AgSCN(s)}$). Predict the colour change and the effect on K_c .

Question 8 Improving the method

Describe two changes to the procedure that would make the final K_c more dependable.