

Equilibrium constants and shifts

AP Chemistry · Lab

Name: _____ Date: _____ Class: _____

Can the equilibrium constant stay the same when the starting concentrations change? You mix iron(III) and thiocyanate ions, which form the blood-red complex FeSCN^{2+} , and measure how much of it forms. Then you disturb the equilibrium and explain each colour change with Q and K .

Level: AP Chemistry · **Curriculum:** AP Chem Unit 7

Aim

Determine K_c for $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{FeSCN}^{2+}(\text{aq})$ from four mixtures, and observe how the equilibrium responds to disturbances.

Equipment

- $\text{Fe}(\text{NO}_3)_3$ solutions in dilute nitric acid, KSCN solution, 0.1 M NaOH
- Test tubes and rack, graduated pipettes, colorimeter with cuvettes
- Hot-water bath (about 60 °C) and ice bath

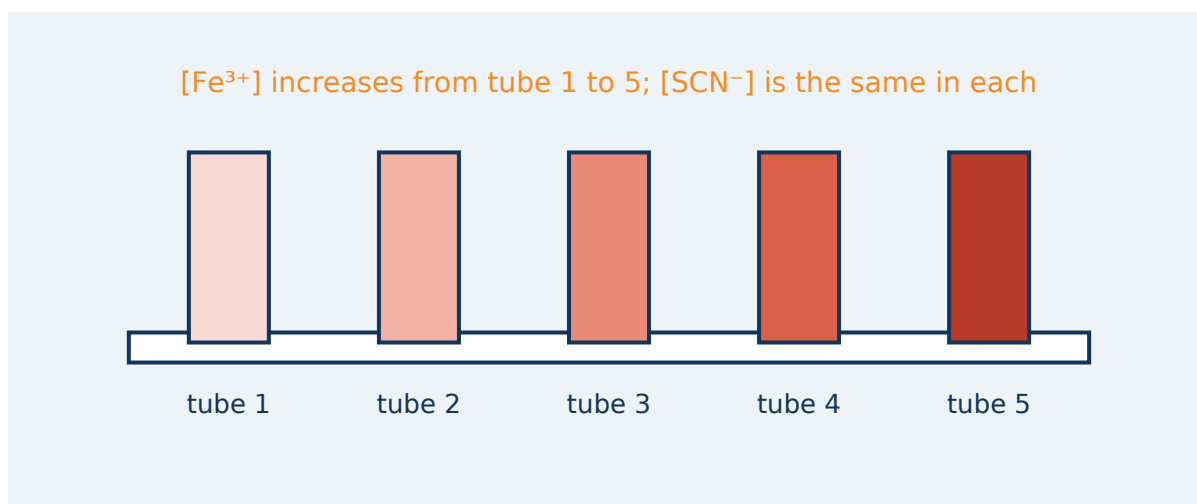
Safety

Safety

Wear eye protection and gloves. Iron(III) nitrate in nitric acid is acidic and stains; potassium thiocyanate is harmful if swallowed and must not be mixed with strong acid. Wipe spills and wash hands. Dispose of solutions as directed by your teacher.

Method

1. Prepare four tubes with 1.00×10^{-3} M SCN^{-} (after mixing) and Fe^{3+} of 1.00, 2.00, 3.00 and 4.00×10^{-3} M (after mixing).
2. Read the colorimeter and use the calibration to find $[\text{FeSCN}^{2+}]$ at equilibrium.
3. To a fresh tube of the equilibrium mixture, add one drop of Fe^{3+} , then SCN^{-} , then 0.1 M NaOH (removes Fe^{3+} as brown $\text{Fe}(\text{OH})_3$); note the colour each time.
4. Warm one tube in the hot bath and cool another in ice.



Set-up: the same SCN⁻ with more and more Fe³⁺ gives deeper red tubes; a colorimeter reads [FeSCN²⁺].

Results

Tube	[Fe ³⁺] ₀ (M)	[SCN ⁻] ₀ (M)	[FeSCN ²⁺] at equilibrium (M)
1	1.00 × 10 ⁻³	1.00 × 10 ⁻³	1.8 × 10 ⁻⁴
2	2.00 × 10 ⁻³	1.00 × 10 ⁻³	3.1 × 10 ⁻⁴
3	3.00 × 10 ⁻³	1.00 × 10 ⁻³	4.1 × 10 ⁻⁴
4	4.00 × 10 ⁻³	1.00 × 10 ⁻³	4.8 × 10 ⁻⁴

Disturbance	Observation
Add Fe ³⁺	Deeper red
Add SCN ⁻	Deeper red
Add NaOH	Paler, brown solid forms
Warm	Paler red
Cool	Deeper red

Analysis questions

Question 1 K expression

Write the expression for K_c and give its units.

Question 2 Tube 1

Complete an ICE table for tube 1 and calculate K_c .

Question 3 Other tubes

Calculate K_c for tubes 2, 3 and 4.

Question 4 Is K constant?

Calculate the mean and the range of K_c and comment on whether it is constant.

Question 5 Explaining the disturbances

Explain the effect of adding Fe^{3+} and NaOH using Le Chatelier's principle and Q .

Question 6 Temperature

Use the colour change on warming to deduce the sign of ΔH for the forward reaction and the effect on K .

Question 7 Dilution

A tube at equilibrium is diluted with an equal volume of water. Predict the shift using Q .