

Equilibrium constants and shifting equilibria

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

The model answers use the sample absorbances in the results table. Check the ICE tables, the units of K_c and the discussion of the standard solution assumption, and compare your own mean K_c with the sample value.

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

Question 1 Complex concentration

$= 2.00 \times 10^{-4} \times A / 0.380$. Tube 1: **$2.474 \times 10^{-4} \text{ mol/dm}^3$** ; tube 2: **$2.237 \times 10^{-4}$** ; tube 3: **$1.926 \times 10^{-4}$** ; tube 4: **$1.505 \times 10^{-4}$** .

Question 2 Initial concentrations

$[\text{Fe}^{3+}]_0 = 0.0200 \times V / 10.0$: **1.00×10^{-2} , 8.00×10^{-3} , 6.00×10^{-3} and $4.00 \times 10^{-3} \text{ mol/dm}^3$** . $[\text{SCN}^-]_0 = 0.00200 \times 2.0 / 10.0 = \textbf{4.00} \times 10^{-4} \text{ mol/dm}^3$ in every tube.

Question 3 Equilibrium concentrations

Each mole of complex formed uses one mole of Fe^{3+} and one of SCN^- . Tube 1: $[\text{Fe}^{3+}] = 1.00 \times 10^{-2} - 2.474 \times 10^{-4} = 9.75 \times 10^{-3}$; $[\text{SCN}^-] = 4.00 \times 10^{-4} - 2.474 \times 10^{-4} = 1.53 \times 10^{-4}$. Tube 2: 7.78×10^{-3} and 1.76×10^{-4} . Tube 3: 5.81×10^{-3} and 2.07×10^{-4} . Tube 4: 3.85×10^{-3} and $2.49 \times 10^{-4} \text{ mol/dm}^3$. **These equilibrium values are used in K_c .**

Question 4 Calculating K_c

$K_c = [\text{Fe}(\text{SCN})^{2+}] / ([\text{Fe}^{3+}][\text{SCN}^-])$. Tube 1: **$166 \text{ dm}^3 \text{ mol}^{-1}$** ; tube 2: **163**; tube 3: **160**; tube 4: **157**.

Question 5 Mean and consistency

Mean $= (166 + 163 + 160 + 157) / 4 = \textbf{1.6} \times 10^2 \text{ dm}^3 \text{ mol}^{-1}$ (161.5). The values agree within about $\pm 3 \%$, as expected because K_c is constant at a fixed temperature, even though the concentrations changed. A small downward trend suggests a systematic effect.

Question 6 Assumption in the standard

The true complex concentration in the standard is about $1.87 \times 10^{-4} \text{ mol/dm}^3$, lower than the 2.00×10^{-4} assumed. Every calculated complex concentration is therefore too high by about 7 %, so the calculated K_c is **too high (about 1.6×10^2 against a true value near 1.4×10^2)**.

Question 7 Prediction with silver ions

SCN^- is removed, so Q becomes greater than K and the equilibrium shifts to the left, making the solution **paler**. K_c is unchanged because the temperature is the same.

Question 8 Improving the method

Use a calibration series of several standards and a calibration graph of absorbance against concentration, and keep all tubes in a thermostatic water bath at one temperature. **Repeat each mixture and average.**