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insight club

Chemistry 205 Report
Chemical Equilibrium

Name: _ Date: 08 - 03 - 2013

Partner: _

Purpose: 1. To review the concepts and principles of chemical equilibrium
2. To study the effects of temperature and concentration changes on the posi[tion] of equilibrium of some reversible reactions
3. To learn the principles of chemical analysis by spectrophotometric means
4. To determine, spectrophotometrically, the equilibrium constant Kc for the reaction between iron III io[n] (Fe^{3+}) and thiocyanate ion (SC[N]) at a given temperature

1. Formation of iron (III) thiocyanate complex ion $FeSCN^{2+}$

1. Compare the color intensity of the cool solution to that of the warm solution
The warm is darker than the cool

Which solution contains more $FeSCN^{2+}$? the warmer solution

In which direction does the equilibrium move when the temperature rises?
Forward, to the right

Which reaction uses up heat? Forward which means the endothermic

Write an equation for the equilibrium reaction including heat as either a reactant or a product
$Fe^{2+} + SCN^- + \text{heat} \rightleftharpoons FeSCN^{2+}$

2. Compare the color with the standard when additional Fe^{3+} is added no change darker

When Fe^{3+} concentration is increased more $FeSCN^{2+}$ is produced.

3. Compare the color with the standard when additional SCN^- is added lighter color darker (-1)

When SCN^- concentration is increased more $FeSCN^{2+}$ is produced.

Increasing the concentration of either of the reactants forces the equilibrium to move to the forward and results in the production of more product

4. Results of adding NaOH Brown precipitate

Equilibrium moved to left

Explanation Fe^{3+} is reduced so it shifts to the left.

Equation $Fe^{3+} + SCN^- + 3\,NaOH \rightleftharpoons Fe(OH)_3$

5. Results of adding $AgNO_3$ yellow precipitate

Equilibrium moved to the left

Explanation SCN^- react with Ag^+ leading to a decrease in concentration of SCN^-

Equation $Ag^+ + SCN^- \rightarrow AgSCN^-$

2. Determination of the equilibrium constant for a chemical reaction

Table 1. Absorption Spectrum of an $FeSCN^{2+}$ Solution

λ (nm)	A	% T
350	/	/
375	/	/
400	0,644	22,7
425	0,866	13,6
450	1,042	9,1
475	0,945	11,3
500	0,779	16,6
525	0,503	31,6
550	0,298	50,4
575	0,171	67,5
600	0,083	82,7

$\lambda_{max} =$ 450 nm

Table 2. Absorbance Measurements of $FeSCN^{2+}$ Standard Solutions

Mixture	Volume of $Fe(NO_3)_3$	Volume of KSCN	Volume of H_2O	% Transmittance	Absorbance	$[FeSCN^{2+}]$
0	5.00	0.00	15.00	100	0	0
1	5.00	0.50	14.50	63,8	0,195	5×10^{-5} M
2	5.00	1.00	14.00	46,2	0,335	1×10^{-4}
3	5.00	1.50	13.50	35,5	0,449	$1,5\times10^{-4}$
4	5.00	2.00	13.00	21,4	0,673	2×10^{-4}
5	5.00	3.00	12.00	9,1	1,042	3×10^{-4}

Slope of Calibration Curve: εb (M^{-1}) = 3426 (calculator)

$n_{SCN^-} = [SCN^-] \times V$

$= 2\times10^{-3} \times 0,5\times10^{-3} = 1\times10^{-6}$ mol

$n_{FeSCN^{2+}} = n_{SCN^-} = 1\times10^{-6}$ mol

$[FeSCN^{2+}] = \frac{n}{V} = \frac{1\times10^{-6}}{20\times10^{-3}} = 5\times10^{-5}$ M

$A = \varepsilon b c$

$C = \frac{A}{\varepsilon b}$

$C = \frac{0.113}{3426} = 3.30 \times 10^{-5}$

Table 3. Composition of Mixtures and Absorbance Measurements of Different Systems at λ_{max}

Mixture	Volume of $Fe(NO_3)_3$	Volume of KSCN	Volume of H_2O	% Transmittance	Absorbance	$[FeSCN^{2+}]$
6	5.00	0.00	5.00	100	0.000	0
7	5.00	1.00	4.00	77.1	0.113	3.30×10^{-5}
8	5.00	2.00	3.00	66.1	0.180	5.25×10^{-5}
9	5.00	3.00	2.00	53.2	0.274	8.00×10^{-5}
10	5.00	4.00	1.00	42.6	0.370	1.16×10^{-4}
11	5.00	5.00	0.00	35.9	0.446	1.30×10^{-4}

Table 4. Equilibrium Concentrations and Equilibrium Constant

Mixture	$n_{0\,Fe^{3+}}$	$n_{0\,SCN^-}$	$n_{Fe^{3+}}$	n_{SCN^-}	$n_{FeSCN^{2+}}$	$[Fe^{3+}]$	$[SCN^-]$	$[FeSCN^{2+}]$	K_c
6	1×10^{-5}	0	1×10^{-5}	0	0	1×10^{-3}	0	0	0
7	1×10^{-5}	2×10^{-6}	9.67×10^{-6}	1.67×10^{-6}	3.3×10^{-7}	9.67×10^{-4}	1.67×10^{-4}	3.30×10^{-5}	204
8	1×10^{-5}	4×10^{-6}	9.48×10^{-6}	3.48×10^{-6}	5.25×10^{-7}	9.48×10^{-4}	3.48×10^{-4}	5.25×10^{-5}	159
9	1×10^{-5}	6×10^{-6}	9.2×10^{-6}	5.2×10^{-6}	8.00×10^{-7}	9.2×10^{-4}	5.2×10^{-4}	8.00×10^{-5}	167
10	1×10^{-5}	8×10^{-6}	8.2×10^{-6}	6.9×10^{-6}	1.1×10^{-6}	8.2×10^{-4}	6.9×10^{-4}	1.1×10^{-4}	194
11	1×10^{-5}	1×10^{-5}	8.7×10^{-6}	8.7×10^{-6}	1.3×10^{-6}	8.7×10^{-4}	8.7×10^{-4}	1.3×10^{-4}	172

$V_{tot} = 10{,}00\ mL$

Show one sample calculation for each calculated quantity (for one mixture only).

(7) $Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$

$n_0 Fe^{3+} = 2 \times 10^{-3} \times 5 \times 10^{-3} = 1 \times 10^{-5}$ mol

$n_0 SCN^- = 2 \times 10^{-3} \times 1 \times 10^{-3} = 2 \times 10^{-6}$ mol

$n_{FeSCN^{2+}} = C \cdot V_{tot} = 3.30 \times 10^{-5} \times 10 \times 10^{-3} = 3.3 \times 10^{-7}$

$n_{Fe^{3+}} = n_0 Fe^{3+} - n_{FeSCN^{2+}} = 9.67 \times 10^{-6}$

$n_{SCN^-} = n_0 SCN^- - n_{FeSCN^{2+}} = 1.67 \times 10^{-6}$

$[Fe^{3+}] = \frac{n_{Fe^{3+}}}{V_{tot}} = \frac{9.67 \times 10^{-6}}{10 \times 10^{-3}}$

$[SCN^-] = \frac{n_{SCN^-}}{V_{tot}} = \frac{1.67 \times 10^{-6}}{10 \times 10^{-3}}$

$K_c = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]} = 204$

Questions

1. Write an expression for the equilibrium constant of the chemical reaction:

$$H_2O_{(g)} + C_{(s)} \rightleftharpoons CO_{(g)} + H_{2(g)}$$

$K'_c = \frac{[CO][H_2]}{[H_2O][C]}$ $K_c = \frac{[CO][H_2]}{[H_2O]} = K'_c[C]$ $[C]$ = constant

2. 10.00 mL of 2.00×10^{-3} M $Fe(NO_3)_3$ are mixed with 4.00 mL of 2.00×10^{-3} M KSCN and 6.00 mL of distilled water are added. The concentration of $FeSCN^{2+}$ is determined spectrophotometrically and found to be 9.04×10^{-5} M. Determine the equilibrium constant Kc of the above reaction.

$Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$

$K_c = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]} = \frac{9{,}04 \times 10^{-5}}{9{,}096 \times 10^{-4} \times 3{,}096 \times 10^{-4}} = 321$ ⟹