3 For a chemical reaction | Oct 29/09

NAME	LAB PARTNER	LOCKER/DESK NO.	COURSE & SECTION NO.
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Purpose: To calculate the value of K_c for the reaction $Fe^{3+}_{(aq)} + SCN^-_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$ from the initial concentration of the reactants and the concentration of the formed $FeSCN^{2+}$ product ~~determined using a spectrophotometer~~; To construct a calibration curve to determine the $[FeSCN^{2+}_{(aq)}]$ formed at equilibrium

Procedure: Please refer to the 2009 Chem 1A03/1E03 lab manual for detailed procedure.
↳ eyedropper used to transfer $Fe(NO_3)_3$ to volumetric flask

Pre-lab:

i) You calibrate the spectrophotometer with a blank solution so that you can use the absorbance of the blank solution as a zero reference when measuring the absorbance of chemical samples. The calibration line is used as a reference point when measuring the absorbance of the unknown sample of chemical substances. So if the chemical substances are prepared in water, the spectrophotometer is blanked with water so that the measurements only reflect the concentration of ~~chem~~ the chemical substances in the solution.

0.3/0.5

relates conc. to absorbance

ii) $Fe^{3+}_{(aq)} + SCN^-_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$

	Fe^{3+}	SCN^-	$FeSCN^{2+}$
I	0.002M	0.003M	0
C	−x	−x	+x
E	0.002 − x	0.003 − x	2.10×10^{-4} M

$x = 2.10\times10^{-4}$ M

~~$K_c = 2.10\times10^{-4}$ M~~

$FeCl_3 \rightleftharpoons Fe^{3+} + Cl^-$
0.002M → 0.002M
$[Fe^{3+}] = 0.002$M

$NaSCN \rightleftharpoons Na^+ + SCN^-$
0.003M → 0.003M
$[SCN^-] = 0.003$M

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

$$K_c = \frac{x}{(0.002-x)(0.003-x)}$$

$$K_c = \frac{2.10\times10^{-4}}{(0.002 - 2.10\times10^{-4})(0.003 - 2.10\times10^{-4})}$$

$K_c = 42.1$ ✗

use final conc.

0.6/1

0.3/0.5

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Observation :

	Before	During	After	Absorbance
1 mL KSCN + $Fe(NO_3)_3$	KSCN, ~~Fe~~ clear, liquid, transparent; $Fe(NO_3)_3$ colourless	-brown gas released -solution turned brown -solution turned light after mixing	-light brown -liquid -translucent	0.102
2mL KSCN + $Fe(NO_3)_3$	both KSCN and $Fe(NO_3)_3$ are colourless, transparent liquid	-brown gas released -solution turned brown after mixing	-brown ~~-~~ liquid -translucent	0.161
3mL KSCN + $Fe(NO_3)_3$	both KSCN and $Fe(NO_3)_3$ are colourless, transparent liquid	-brown gas released -solution turned brown -solution turned dark brown after mixing	~~dark brown~~ -dark brown -liquid -translucent	0.237

Test tube	1	2	3	4	5
mL KSCN	1.00	2.00	3.00	4.00	5.00
mL $Fe(NO_3)_3$	5.00	5.00	5.00	5.00	5.00
mL H_2O	4.00	3.00	2.00	1.00	—
Qualitative Observations	~~light brown~~ ~~liquid~~ ~~translucent~~ -light yellow brown -translucent -liquid	-light brown -translucent -liquid	- orange/brown -translucent -liquid	- brown -translucent -liquid	-dark brown -liquid -translucent
Absorbance	0.049	0.097	0.132	0.174	0.214

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1mL of KSCN $A = 0.102$

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

	SCN^-	$FeSCN^{2+}$
c	0.002M	4×10^{-5}M
v	0.001L	0.05L
n	2×10^{-6} mol	2×10^{-6} mol

$A = y[FeSCN^{2+}]$

$0.102 = y(4 \times 10^{-5})$

$y \doteq 2550$

$V_f = 0.05L$

$[SCN^-]_{initial} = C_f = \frac{n}{V_f} = \frac{2 \times 10^{-6} mol}{0.05L} = 4 \times 10^{-5}M = [FeSCN^{2+}]$

LP $\frac{7}{10}$

2mL of KSCN $A = 0.161$

~~$[SCN^-]_{initial} = 0.002M$~~

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

	SCN^-	$FeSCN^{2+}$
c	0.002M	8×10^{-5}M
v	0.002L	0.05L
n	4×10^{-6} mol	4×10^{-6} mol

$A = y[FeSCN^{2+}]$

$0.161 = y(8 \times 10^{-5}M)$

$y \doteq 2010$

3mL of KSCN $A = 0.232$

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

	SCN^-	$FeSCN^{2+}$
c	0.002M	1.2×10^{-4}M
v	0.003L	0.05L
n	6×10^{-6} mol	6×10^{-6} mol

$A = y[FeSCN^{2+}]$

$0.232 = y(1.2 \times 10^{-4}M)$

$y = 1930$

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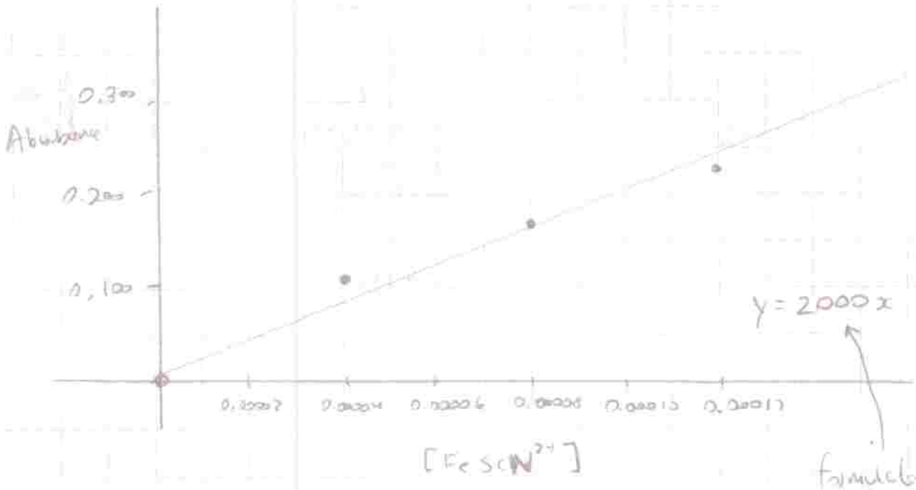
Calibration Curve

$[FeSCN^{2+}]$	Absorbance
0	0
0.00004	0.102
0.00008	0.161
0.00012	0.232

Calibration Curve of $FeSCN^{2+}$ ions



$y = 2000x$

formulated using excel

Part B

Test tube 1 Absorbance of Test tube 1 = 0.049

y (formulated from graph) = 2000

$A = y\,[Conc]$

$0.049 = 2000\,[\text{Conc of } FeSCN^{2+} \text{ at eq}]$

$[FeSCN^{2+}] = $ ~~[illegible]~~ $2.45 \times 10^{-5}\ M$

Test tube 2 $A = y\,[FeSCN^{2+}]$

$[FeSCN^{2+}] = \cancel{\frac{2000}{0.097}}\ \frac{0.097}{2000} = 4.85 \times 10^{-5} M$

Test tube 3 $[FeSCN^{2+}] = \cancel{\frac{2000}{0.132}} = \frac{0.132}{2000} = 6.60 \times 10^{-5} M$

Test tube 4 $[FeSCN^{2+}] = \cancel{\frac{2000}{0.174}} = \frac{0.174}{2000} = 8.70 \times 10^{-5} M$

Test tube 5 $[FeSCN^{2+}] = \cancel{\frac{2000}{0.214}} = \frac{0.214}{2000} = 1.07 \times 10^{-4} M$

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Calculations for Part B

Test tube 1

	$KSCN \rightleftharpoons$	K^+ + SCN^-
C	0.002M	2×10^{-4} M
V	0.001L	0.01L ← total volume
n	2×10^{-6} mol →	2×10^{-6} mol

	$Fe(NO_3)_3 \rightleftharpoons$	Fe^{3+} + NO_3^-
C	0.002M	1×10^{-3} M
V	0.005 L	0.01L ← total volume
n	1×10^{-5} mol →	1×10^{-5} mol

$[SCN^-]_{initial} = 2\times10^{-4}$ M

$[Fe^{3+}]_{initial} = 1\times10^{-3}$ M

	Fe^{3+} +	$SCN^- \rightleftharpoons$	$FeSCN^{2+}$
I	1×10^{-3} M	2×10^{-4} M	0
C	$-x$	$-x$	$+x$
E	$1\times10^{-3} - x$	$2\times10^{-4} - x$	$x = 2.45\times10^{-5}$ M

$[FeSCN^{2+}]_{eq} = 2.45\times10^{-5}$ M

$[Fe^{3+}]_{eq} = 1\times10^{-3} - 2.45\times10^{-5}$
$= 9.755\times10^{-4}$ M

$[SCN^-]_{eq} = 2\times10^{-4} - 2.45\times10^{-5}$
$= 1.755\times10^{-4}$ M

$K_c = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$
$= \frac{2.45\times10^{-5}}{(9.755\times10^{-4})(1.755\times10^{-4})}$

$K_1 \approx 143$

Test tube 2

	$KSCN \rightleftharpoons$	K^+ + SCN^-
C	0.002M	4×10^{-4} M
V	0.002L	0.01L
n	4×10^{-6} mol →	4×10^{-6} mol

$[SCN^-]_{initial} = 4\times10^{-4}$ M

$[Fe^{3+}]_{initial} = 1\times10^{-3}$ M
(same as test tube 1)

$[FeSCN^{2+}]_{eq} = 4.85\times10^{-5}$ M

	Fe^{3+} +	$SCN^- \rightleftharpoons$	$FeSCN^{2+}$
I	1×10^{-3} M	4×10^{-4} M	0
C	$-x$	$-x$	$+x$
E	$1\times10^{-3} - x$	$4\times10^{-4} - x$	$x = 4.85\times10^{-5}$ M

$[Fe^{3+}]_{eq} = 1\times10^{-3} - 4.85\times10^{-5}$
$= 9.515\times10^{-4}$ M

$[SCN^-]_{eq} = 4\times10^{-4} - 4.85\times10^{-5}$
$= 3.515\times10^{-4}$ M

$K_c = \frac{4.85\times10^{-5}}{(9.515\times10^{-4})(3.515\times10^{-4})}$

$K_2 \approx 145$

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Test tube 3

$$KSCN \rightleftharpoons K^+ + SCN^-$$

c 0.002M 6×10^{-4}M

v 0.003L 0.01L

n 6×10^{-6}mol $\longrightarrow$ 6×10^{-6}mol

$[SCN^-]_{initial} = 6 \times 10^{-4}$ M

$[Fe^{3+}]_{initial} = 1 \times 10^{-3}$ M

$[FeSCN^{2+}]_{eq} = 6.6 \times 10^{-5}$ M

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

c 1×10^{-3} 6×10^{-4} 0

v $-x$ $-x$ $+x$

n $1 \times 10^{-3} - x$ $6 \times 10^{-4} - x$ $x = 6.6 \times 10^{-5}$

$$K_c = \frac{6.6 \times 10^{-5}}{(9.34 \times 10^{-4})(5.34 \times 10^{-4})}$$

$K_3 \approx 132$

$[Fe^{3+}]_{eq} = 1 \times 10^{-3} - 6.6 \times 10^{-5}$
$= 9.34 \times 10^{-4}$ M

$[SCN^-]_{eq} = 6 \times 10^{-4} - 6.6 \times 10^{-5}$
$= 5.34 \times 10^{-4}$ M

Test tube 4

$$KSCN \rightleftharpoons K^+ + SCN^-$$

c 0.002M 8×10^{-4}M

v 0.004L 0.01L

n 8×10^{-6}mol $\longrightarrow$ 8×10^{-6}mol

$[SCN^-]_{initial} = 8 \times 10^{-4}$ M

$[Fe^{3+}]_{initial} = 1 \times 10^{-3}$ M

$[FeSCN^{2+}]_{eq} = 8.70 \times 10^{-5}$ M

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

c 1×10^{-3} 8×10^{-4} 0

v $-x$ $-x$ $+x$

n $1 \times 10^{-3} - x$ $8 \times 10^{-4} - x$ $x = 8.7 \times 10^{-5}$

$$K_c = \frac{8.7 \times 10^{-5}}{(9.13 \times 10^{-4})(7.13 \times 10^{-4})}$$

$K_4 \approx 134$

$[Fe^{3+}]_{eq} = 1 \times 10^{-3} - 8.7 \times 10^{-5}$
$= 9.13 \times 10^{-4}$ M

$[SCN^-]_{eq} = 8 \times 10^{-4} - 8.7 \times 10^{-5}$
$= 7.13 \times 10^{-4}$ M

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Test tube 5

$$KSCN \rightleftharpoons K^+ + SCN^-$$

c $0.002M$ — $1\times10^{-3}M$ → $[SCN^-]_{initial} = 1\times10^{-3}M$

v $0.005L$ — $0.01L$

n $1\times10^{-5}ml$ → $1\times10^{-5}ml$

$[Fe^{3+}]_{initial} = 1\times10^{-3}M$

$[FeSCN^{2+}]_{eq} = 1.07\times10^{-4}M$

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

	Fe^{3+}	SCN^-	$FeSCN^{2+}$
I	1×10^{-3}	1×10^{-3}	0
C	$-x$	$-x$	$+x$
E	$1\times10^{-3}-x$	$1\times10^{-3}-x$	$x = 1.07\times10^{-4}$

$$K_c = \frac{1.07\times10^{-4}}{(8.93\times10^{-4})^2}$$

$K_5 \approx 134$

$[Fe^{3+}] = [SCN^-] = 1\times10^{-3} - 1.07\times10^{-4}$
$= 8.93\times10^{-4}$

Calculated K_c values

	K_c
Test tube 1	143
" 2	145
" 3	132
" 4	134
" 5	134

$$\text{Average } K_c = \frac{143 + 145 + 132 + 134 + 134}{5}$$

≈ 138

∴ The K_c for the reaction $Fe^{3+} + SCN^- \rightleftharpoons FeSCN^-$ is 138

~~Discussion / Sources of error:~~

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