Chemistry TAS Report

1. Experiment Number : 10
2. Date : 18/01/2008
3. Title : Determination of the equilibrium constant for the reaction :

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

4. Aims/Objective :

   To determine the equilibrium constant for the reaction :

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

5. Introduction / Theory:

   In this experiment, the equilibrium constant for the formation of a complex ion, $FeSCN^{2+}_{(aq)}$, is determined.

   Complex ions, thiocyanatoiron(III) ions, are formed from iron(III) ions and thiocyanate ions in aqueous solution :

   $$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \Leftrightarrow FeSCN^{2+}_{(aq)} \qquad (1)$$

   The equilibrium constant for this reaction is:

   $$K_c = \frac{[FeSCN^{2+}_{(aq)}]}{[Fe^{3+}_{(aq)}][SCN^{-}_{(aq)}]} \qquad (2)$$

   The product complex ion is the only one of the three species which has an appreciable color (blood-red).

6. Relevant Equations/Chemical Reactions Involved :

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

7. Chemicals :

0.002 M	$KSCN_{(aq)}$	50 cm^3
0.2 M	$Fe(NO_3)_{3(aq)}$	20 cm^3

8. Apparatus and equipment :

Boiling tube	5	Dropper	2
10 cm^3 measuring cylinder	1	Lamp	1
25 cm^3 measuring cylinder	1	Wash bottle	1
Safety spectacle	1	250 cm^3 beaker	1

9. Procedure :
    1. 0.2 M $Fe(NO_3)_{3(aq)}$ was used and 10 cm^3 of 0.08 M, 0.032 M, 0.0128 M, 0.00512 M $Fe(NO_3)_{3(aq)}$ were prepared respectively.
    2. The solutions were added by using 10 cm^3 measuring cylinder to 5 clean boiling tubes in a rack as below.

Tube No.	1	2	3	4	5
$SCN^-_{(aq)}$ / cm^3	10	10	10	10	10
$Fe^{3+}_{(aq)}$ / cm^3	10(0.2 M)	10(0.08 M)	10(0.032 M)	10(0.0128 M)	10(0.00512 M)

    3. Tubes 1 and 2 were wrapped around with a strip of paper so that light was excluded from the side.
    4. The solutions towards the lamp were looked vertically down to compare the colour intensity.
    5. Some of the solution from the standard tube 1 was removed with a dropper until the colour intensities of solutions in both tubes were the same. And the removed liquid was put into a clean and dry beaker.
    6. The depth of the solution in tube 1 was then measured.
    7. Steps 3 to 6 were repeated with tubes 1 and 3, 1and 4 and finally 1and 5.

10. Observations :
    The colour intensities of the solutions in the two tubes being observed were the same.

11. Data, Calculation and Results :
    - Height of solution in original tube 1 = 59 mm
    - Height of solution in tube 1 having the same colour intensity as tubes 2, 3, 4 and 5 are :

Same colour intensity as	2	3	4	5
Height of solution in tube 1 (mm)	45	35	28	23

12. Conclusion :
    The equilibrium constant for the reaction : $Fe^{3+}_{(aq)} + SCN^-_{(aq)} \Leftrightarrow FeSCN^{2+}_{(aq)}$ was found to be 82.1 M^{-1}.

13. Discussion :
    1. By $M_1V_1 = M_2V_2$,
       For tube 1, initial concentration of $SCN^-_{(aq)}$ = 0.001 M
       initial concentration of $Fe^{3+}_{(aq)}$ = 0.1 M

For tube 2, initial concentration of $SCN^-_{(aq)}$ = 0.001 M
initial concentration of $Fe^{3+}_{(aq)}$ = 0.04 M
For tube 3, initial concentration of $SCN^-_{(aq)}$ = 0.001 M
initial concentration of $Fe^{3+}_{(aq)}$ = 0.016 M
For tube 4, initial concentration of $SCN^-_{(aq)}$ = 0.001 M
initial concentration of $Fe^{3+}_{(aq)}$ = 0.0064 M
For tube 5, initial concentration of $SCN^-_{(aq)}$ = 0.001 M
initial concentration of $Fe^{3+}_{(aq)}$ = 0.00256 M

2. Concentration of $FeSCN^{2+}$ in tube 1 = 0.001 M
3. Ratio of depth in the colour comparison with tube 2
   = 45 /59
   = 0.763
   Ratio of depth in the colour comparison with tube 3
   = 35 /59
   = 0.593
   Ratio of depth in the colour comparison with tube 4
   = 28 /59
   = 0.475
   Ratio of depth in the colour comparison with tube 5
   = 23 /59
   = 0.390
   Equilibrium concentration of thiocyanoiron(III) ions:
   In tube 2 = 0.001 x (45 / 59) = 7.63×10^{-4} M
   In tube 3 = 0.001 x (35 / 59) = 5.93×10^{-4} M
   In tube 4 = 0.001 x (28 / 59) = 4.75×10^{-4} M
   In tube 5 = 0.001 x (23 / 59) = 3.90×10^{-4} M
4. $[Fe^{3+}]_{equil} = [Fe^{3+}]_{initial} - [FeSCN^{2+}]_{equil}$
   $= 0.04 - 7.63 \times 10^{-4}$
   = 0.0392 M
   $[SCN^-]_{equil} = [SCN^-]_{initial} - [FeSCN^{2+}]_{equil}$
   $= 0.001 - 7.63 \times 10^{-4}$
   $= 2.37 \times 10^{-4}$ M
5. Room temperature = 16 °C
   $K = [FeSCN^{2+}]_{equil} / ([Fe^{3+}]_{equil}[SCN^-]_{equil})$
   $= 7.63 \times 10^{-4} / [(0.0392)(2.37 \times 10^{-4})]$
   $= 82.1\ M^{-1}$

6. There are few sources of error in this experiment.
   (1) Determination of colour intensity in the two tubes observed might

not be accurate.

(2) Taking reading when measuring the depth of liquid.

Error estimation -

When taking initial reading, error is $\pm$ 0.05 cm^3.

When taking final reading, error is also $\pm$ 0.05 cm^3.

Therefore, error is $\pm$ 0.1 cm^3.