KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

TITLE: FORMULA FOR A COMPLEX SPECIES

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Aims and Objectives:

1. To determine the absorption spectra.
2. To determine the formula of a complex iron (iii) species containing water and thiocyanate ligands by using Beer's law and the method of continuous variation. (Job's method).
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INTRODUCTION

An ion is a charged atom or molecule that results from the loss or gain of electrons. A complex ion is an ion containing a central metal cation bonded to one or more molecules or ions. Complexes are very important in many chemical and biological reaction and processes.

Transition metals however have the tendency to produce complex ions because they have the ability to form more than one oxidation state. This property helps them easily to form complex ions.

In acidic aqueous solution, hydrated Fe3+ ion interacts with thiocyanate ion SCN- to establish a series of equilibria.

1. $[Fe(H_2O)_6]^{3+} + SCN^-$ $[Fe(SCN)(H_2O)_5]^{2+} + H_2O$

2. $[Fe(SCN)(H_2O)_5]^{2+} + SCN^-$ $[Fe(SCN)_2(H_2O)_4]^{+} + H_2O$

… Etc.

6. $[Fe(SCN)_5(H_2O)]^{+} + SCN^-$ $[Fe(SCN)_6]^{3-} + H_2O$.

The main aim of the experiment is to find out the most stable iron thiocyanate complex. This complex absorbs blue light and the resulting solution has a deep red colour. The formula can therefore be determined by measuring the absorbance of light with a spectro photometer and analysing the data using the method of continuous variation technique in which the stable complex ion is found from a selected wavelength.

APPARATUS AND CHEMICALS

1. Burette
2. Test Tube
3. Test tube rack
4. Spectro photometer
1. Solution containing Fe^{3+}
2. Solution containing SCN^-

PROCEDURE

PREPARATION OF THE SOLUTIONS

The solution was prepared in a stock room, and buffered with a pH of 2.
Solution A contained iron (III) ions and was prepared by dissolving 7.715 g of $FeNH_4(SO_4)_2.12H_2O$ in the buffer solution.
Solution B contained SCN^- ions and was prepared by dissolving 1.218 g of NH_4SCN in the buffer solution.

1. Eleven test tubes were numbered from 0 to 10.
2. Two burettes were filled with solutions A and B separately.

3. An exact volume of each of the two solutions was delivered into each test tube as specified in the table.
4. Two solutions added up to give 10 ml in each case.
5. Each solution was mixed and was allowed to equilibrate for at least 10 minutes.
6. The solutions were later taken to the spectro photometer where the absorption spectra and percentage transmittance of each solution was obtained.

TABLE OF VALUES

Test tube	mL soln A of Fe3+	Moles of Fe3+	mL soln B of SCN	Moles of SCN-	absorbance	%T
0	10	4×10^{-5}	0	0.0	-0.010	0.00
1	9	3.6×10^{-5}	1	4.0×10^{-6}	0.121	90.9
2	8	3.2×10^{-5}	2	8.0×10^{-6}	0.219	89.1
3	7	2.8×10^{-5}	3	1.2×10^{-5}	0.323	85.8
4	6	2.4×10^{-5}	4	1.6×10^{-5}	0.396	82.3
5	5	2.0×10^{-5}	5	2.0×10^{-5}	0.395	73.6
6	4	1.6×10^{-5}	6	2.4×10^{-5}	0.413	79.4
7	3	1.2×10^{-5}	7	2.8×10^{-5}	0.359	86.0
8	2	8.0×10^{-6}	8	3.2×10^{-5}	0.290	87.4
9	1	4.0×10^{-6}	9	3.6×10^{-5}	0.162	79.3
10	0	0.0	10	4.0×10^{-5}	0.011	0.00

CALCULATIONS

Mass of $FeNH_4(SO_4)_2.12H_2O$ = 7.715 g
Volume of solution = 4.0 L

Therefore Molar mass of $FeNH_4(SO_4)_2.12H_2O$
= 56 + 14 + 4(1) + 32 x2 + 64 x 2 + 12 x 18 = 482 g/mol

Mass (Fe^{3+}) = (56 / 482) x 7.715 g = 0.896 g

Concentration of Fe^{3+} = m / MV = 0.896 / (56 x 4) = 4.00 mol/l = 4.0×10^{-6} M

Number of moles of iron (III) at the different volumes, n = C x V

At V = 10 ml, it implies that
n = 4.0×10^{-6} x 10 ml = 4.0×10^{-5} mol.
This is repeated for all the other volumes from 9ml to 0ml and the values imputed into the table of results

Mass of NH_4SCN = 1.218 g
Volume of solution = 4.0 L

Molar mass of SCN^- = 32 + 12 + 14 = 58 g/mol

Molar mass of NH4SCN = 18 + 58 = 76 g/mol

Mass of SCN^- = (58 / 76) x 1.218 g = 0.93 g

Concentration of SCN^- = m / MV = 0.93 / (58 x 4) = 4.0 x 10^{-6} mol/ml or mol/dm^3.
n = 4.0 x 10-6 x 0 ml = 0 mol
This is also repeated for the other volumes from 1ml to 10ml and the values imputed into the table of results.

DISCUSSION

According to Beer's Law, concentration of a dilute compound is proportional to its absorbance of light. To examine this absorbance, the UV spectrophotometer is used
In this experiment, the concentration of the unidentified complex is examined by the absorption procedure. This concentration is dependent on the relative amounts of Fe^{3+} and SCN^- in solution.
The least absorbencies were observed when the solutions contained only one of the ions under consideration (i.e. Fe^{3+} and SCN^-). This is because the complex which gives the colour and hence absorbs light is not formed.
It can also be observed that as the amount of the thiocyanate increased, the absorbance also increased until it got to a peak value where it begun to fall. This can be explained by the fact that, the ratio (SCN^-/Fe^{3+}) for maximum amount of the complex to be formed was being neared as the amount of thiocyanate increased and the iron (III) decreased. The peak value for absorbance was observed when the ratio equalled n, the ratio for the highest amount of complex that could be formed under the given conditions. From the graph, this absorbance occurred at the point where the amounts of Fe^{3+} and SCN^- were the same.

PRECAUTIONS

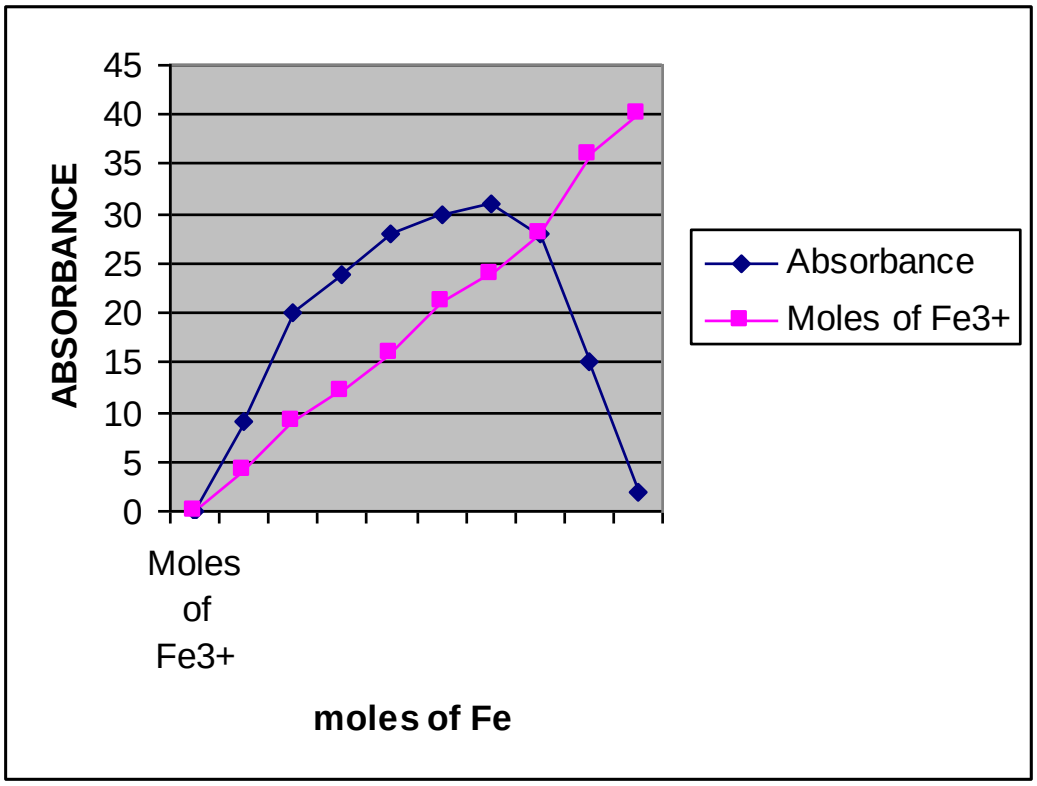
1. All volumes were read at the meniscus.
2. All apparatus were washed before the experiment to minimise any errors.
3. Solutions were carefully disposed off in the hood.
4. Hands were washed before leaving the laboratory.

CONCLUSION

With amounts of the thiocyanate and iron (III) being the same, that is N = 2 x 10 / 2x 10 with n equals 1.
Therefore, the stable complex formed under the given conditions of this experiment is $[Fe(SCN)(H_2O)_5]^{2+}$ from the general formula for the complex is $[Fe(SCN)_n(H_2O)_{6-n}]^{3-n}$.
From the discussion, we can conclude that by using the Beer's law and the method of continuous variation, the absorption spectra and the formula of complexes and their ligands can be determined.

REFERENCES

General Chemistry Practicals pages 44-46.
Concise Inorganic Chemistry, Fifth Edition by J.D Lee pages 227 to 236.


45
40
35
30
25
20
15
10
5
0
ABSORBANCE
Moles of Fe3+
moles of Fe
Absorbance
Moles of Fe3+