**LABORATORY REPORT**

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| **FORMULA FOR A COMPLEX SPECIES** |
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| **AIMS/OBJECTIVES:**   1. 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). 2. To determine the absorption spectra. 3. To determine or find out the most stable iron thiocyanate complex. |
| **INTRODUCTION/THEORY:**  A complex ion or molecule comprises a central metal atom or ion and a number of ligands closely attached to the former.  The relative amount of these components in a stable complex seems to follow a well defined stoichiometry.  The central atom can be characterized by the coordination number, which shows the number of ligands attached which may form a stable complex with one central atom. For example, the coordination number of Fe2+, Fe2+, Fe3+, Zn2+, Cr3+, Co3+, Ni2+, Cd2+is 6 sometimes 4 (as with Cu2+, Cu+, Pt2+) and 8 (some ions in the platinum group) do group.    The coordination number represents the available space around the central atom or ion in the coordination sphere each of which can be occupied by a (monodentate) ligand. The arrangement of ligands around the central ion is symmetrical.  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 more because they have the ability to form more than one oxidation state.  In acidic aqueous solution, hydrated Fe3+ ion interacts with thiocyanate ion SCN- to establish a series of equilibria.  1. [Fe(H2O)6]3+ + SCN- ------ [Fe(SCN)(H2O)5]2+ H2O  2. [Fe(SCN)(H2O)5]2+ + SCN- --------- [Fe(SCN)2(H2O)4]+ H2O    The main aim of the experiment is to find out the most stable iron thiocyanate complex. This complex absorbs blue light. The formula can therefore be determined by measuring the absorbance of light with a spectrophotometer and analyzing the data using the method of continuous variation technique in which the stable complex ion is found from a selected wavelength. |
| **CHEMICALS & EQUIPMENT:**  1. Burette  2. Test Tube  3. Test tube rack  4. Spectro photometer  1. Solution containing Fe3+  2. Solution containing SCN- |
| **PROCEEDURE:**  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 FeNH4 (SO4)2.12H2O in the buffer solution.  Solution B contained SCN- ions and was prepared by dissolving 1.218 g of NH4SCN 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/ CALCULATIONS**   1. Wavelength = 470nm  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Test tube | mL soln A of Fe3+ | Moles of Fe3+ | mL soln B of SCN | Moles of SCN- | Mixture A&B | absorbance | %T | | 0 | 10 | 4 x 10-5 | 0 | 0.0 | 10+0 | 0.15 | 71 | | 1 | 9 | 3.6 x 10-5 | 1 | 4.0 x10-6 | 9+1 | 0.23 | 59 | | 2 | 8 | 3.2 x 10-5 | 2 | 8.0 x 10-6 | 8+2 | 0.37 | 43 | | 3 | 7 | 2.8 x 10-5 | 3 | 1.2 x 10-5 | 7+3 | 0.39 | 41 | | 4 | 6 | 2.4 x 10-5 | 4 | 1.6 x 10-5 | 6+4 | 0.41 | 39 | | 5 | 5 | 2.0 x 10-5 | 5 | 2.0 x 10-5 | 5+5 | 0.35 | 44 | | 6 | 4 | 1.6 x 10-5 | 6 | 2.4 x10 -5 | 4+6 | 0.40 | 40 | | 7 | 3 | 1.2 x 10-5 | 7 | 2.8 x 10-5 | 3+7 | 0.38 | 42 | | 8 | 2 | 8.0 x 10-6 | 8 | 3.2 x 10-5 | 2+8 | 0.30 | 50 | | 9 | 1 | 4.0 x 10-6 | 9 | 3.6 x 10-5 | 1+9 | 0.26 | 55 | | 10 | 0 | 0.0 | 10 | 4.0 x 10-5 | 0+10 | 0.16 | 70 | |
| **CALCULATIONS:**  *Pre-Lab questions*  Mass of FeNH4(SO4)2.12H2O = 7.715 g  Volume of solution = 4.0 L  Therefore Molar mass of FeNH4(SO4)2.12H2O  = 56 + 14 + 4(1) + 32 x2 + 64 x 2 + 12 x 18 = 482 g/mol  Mass (Fe3+) = (56 / 482) x 7.715 g = 0.896 g  Concentration of Fe3+ = m / MV = 0.896 / (56 x 4) = 4.00 mol/l = 4.0 x 10-6 M  Number of moles of iron (III) at the different volumes, n = C x V  Mass of FeNH4(SO4)2.12H2O = 7.715 g  Volume of solution = 4.0 L  Therefore Molar mass of FeNH4(SO4)2.12H2O  = 56 + 14 + 4(1) + 32 x2 + 64 x 2 + 12 x 18 = 482 g/mol  Mass (Fe3+) = (56 / 482) x 7.715 g = 0.896 g  Concentration of Fe3+ = m / MV = 0.896 / (56 x 4) = 4.00 mol/l = 4.0 x 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 x 10-6 x 10 ml = 4.0 x 10-5 mol.  At V=9ml, n= 4.0 x 10-6 x 9ml=3.6 x 10-5  At V= 8ml, n= 4.0 x 10-6 x 8ml=3.2 x 10-5  At V=7ml, n= 4.0 x 10-6 x 7ml=2.8 x 10-5  At V=6ml, n=4.0 x 10-6 x 6ml=2.4 x 10-5  At V=5ml, n=4.0 x 10-6 x 5ml=2.0 x 10-5  At V=4ml, n=4.0 x 10-6 x 4ml=1.6 x 10-5  At V=3ml, n=4.0 x 10-6 x 3ml=1.2 x 10-5  At V= 2ml, n=4.0 x 10-6 x 2ml=8.0 x 10-6  At V=1ml, n=4.0 x 10-6 x 1ml=4.0 x 10-6  At V =0ml, n=4.0 x 10-6 x 0ml=0  Mass of NH4SCN = 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/dm3.   1. The maximum absorbance is 0.41.   The number of moles of Fe and A at the maximum absorbance is 6mols.   1. The species would have an absorbance of 0.15 and percent transmittance of 71% if it were completely transparent. 2. The species would have an absorbance of 0.41 and percent transmittance of 39% if it were opaque completely |
| **DISCUSSION:**  From the experiment, the extent of the reaction between Fe3+ and SCN- could be measured by a spectrophotometer. The stable coloured complex formed absorbs light in the visible light region at a wavelength of 470 nm. According to Beer-Lambert Law, when the solution of the coloured complex is dilute, the absorbance of light will be proportional to the concentration of the complex in the solution.  An opaque object is that which does not allow light to pass through it, thus opaque objects have the highest absorbance.  From the experiment, the solution was colourless in test tubes 0 and 10, light orange in test tubes 1 and 9 and was orange in test tubes 2 to 8. Test tube 4 was deep orange in colour and as such recorded the highest absorbance of 0.41 and the least transmittance of 39%.  Also a transparent object is that object which will allow the maximum amount of light to pass through it, thus having the lowest absorbance and the highest transmittance.  Test tube 10 was close to colourless and as such recorded the lowest absorbance of 0.15 and the highest transmittance of 71%. |
| **ERROR ANALYSIS:**   1. The remaining water droplets in the washed apparatus could have altered the expected concentrations of the solutions. |
| **PRECAUTIONS:**   1. All apparatus were washed before the experiment to reduce any errors in the experiment 2. All the volume readings were carefully read from the bottom of the meniscus for clear solutions, and the top of the meniscus for strongly coloured solutions. 3. Solutions were carefully handled and disposed off to prevent accidents to the skin and in the laboratory. |
| **CONCLUSION:**  Opaque objects have the highest absorbance and thus the lowest transmittance whiles transparent objects have the lowest absorbance and the highest transmittance.  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. |
| **REFRENCES:**   1. J.D Lee, Concise Inorganic Chemistry, Fifth Edition, Pp. 227 to 236. 2. General Chemistry Practical, Pp. 44-46. |