**\ LABORATORY REPORT**

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| ELECTRON ABSORBPTION SPECTRA OF SOME Cu (II) COMPLEXES |
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| **AIMS/OBJECTIVES:**  The aims of this experiment are:   1. To determine crystal field splitting energies of some Cu (II) complexes. 2. To measure the electronic absorption spectra for some complexes of Cu (II) complexes. 3. To learn to operate the ultra-violet/visible spectrophotometer. |
| **INTRODUCTION/THEORY:**  Transition metals refer to the elements on the periodic table with partially filled d-orbital.  Transition metals are characteristic for the formation of coloured compounds. When transition metals absorb energy, they become excited and very unstable; as a result they soon de-excite to release energy in the form of electromagnetic radiations with a particular wavelength.  The energy absorption, excitation and de-excitation processes usually occur in the visible region of the electromagnetic spectrum hence, the compounds appear visible and coloured to the human eye.  Several theories are used to relate electronic absorption spectra to electronic structure. One of these is the Crystal Field Theory (CFT) which relates electronic absorption spectra to electronic structure by giving account for both the colour and magnetic properties of many coordination compounds.  This theory explains the bonding in complex ions purely in terms of electrostatic forces.  The d-orbitals have different orientations, but in the absence of external disturbance, they all have the same energy (degenerate). In the presence of these electrostatic field generated by the ligands, the degenerate d-orbitals split between two energy levels: a higher level with two orbitals (dx2-y2 and dz2) which form the axial set and represented by the symbol **eg** and a lower level with three equal energy orbitals (dxy, dyz and dxz) forming the inter-axial set represented by the symbol **t2g**.  The energy difference between these two energy level d-orbitals is called the *crystal splitting energy* and is given the symbol Δ0. The magnitude of ∆0 depends on the metal and the nature of the ligands. ∆0 has a direct effect on the colour and magnetic properties of complex ions.  For a given metal ion in an octahedral field, the value of Δo depends on the nature of the ligand. Different ligands cause different degrees of splitting of the d orbitals. The list of ligands in order of their capacity to cause d orbital splitting is known as spectrochemical series.  In this experiment, the electronic absorption spectra of some Cu (II) complexes are going to be measured and recorded and their crystal field splitting energies would be determined. |
| **CHEMICALS & EQUIPMENT:**   1. Calorimeter 2. An electric burner 3. Beakers 4. Measuring cylinder 5. Volumetric flask 6. Fume chamber 7. 1 M copper (II) nitrate solution. 8. 1 M ammonia solution 9. 2 M ammonia solution 10. 3 M ammonia solution 11. 2 M ammonium nitrate solution 12. Concentrated ammonia solution 13. Distilled water 14. EDTA solution 15. Solid glycine |
| **PROCEEDURE:**  *Preparation of the complexes [Cu (NH3) n (H2O) 6-n] 2+*  Using a pipette, 1.0 cm3 of the 1 M Cu (NO3)2 stock solutions was diluted to 50 cm3 in a volumetric flask. For n=1, 5.0 cm3 of the 1 M Cu(NO3)2 solution was pipette into a small beaker and 14 g of solid ammonium nitrate was added. The solution was stirred and warmed to about 30°C using a stirrer. 5 cm3 of 1 M NH3 was added and stirring continued until the temperature reached 30°C again. 1 cm3 of the solution was diluted to 25 cm3 with 2 M NH4NO3 solution.  For n=2 and n=3, the same method was used as outlined for n=1 but 1 M NH3 was replaced with 2 and 3 M NH3 respectively. For n=4, 1 cm3 of concentrated NH3 was added to 1 cm3 of 1 M Cu(NO3)2 and diluted to 50cm3 with water.  *Preparation of the complex [Cu (en) 2(H2O) 2]2+.*  1 cm3 of the 1 M Cu (NO3)2 solutions were pipette into a 50 cm3 volumetric flask. EDTA was added to give a concentration of 0.4 M ethylenediamine solution into a 50 cm3 volumetric flask and made to the mark with distilled water.  *Preparation of the complex [Cu (gly) 2(H2O) 2]2+*  1 cm3 of the 1 M Cu (NO3)2 solutions was pipette into a 50 cm3 volumetric flask and solid glycine added to give a concentration of 0.04 M. 20 cm3 of 0.1 M NaOH was added and made to the mark with distilled water.  **TABLE OF RESULTS**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Ligand(NH3) n | Absorbance(A) | Wavelength | 1/wavelength (nm-1) | 1/wavelength×107 (nm-1) | ∆◦ = (1/wavelength)×107×A(nm-1) | | 0 | 0.00 | 490 | 2.041×10-3 | 2.041×104 | 0.00 | | 1 | 0.01 | 490 | 2.041×10-3 | 2.041×104 | 204.10 | | 2 | 0.09 | 490 | 2.041×10-3 | 2.041×104 | 1836.10 | | 3 | 0.11 | 490 | 2.041×10-3 | 2.041×104 | 2245.10 | | 4 | 0.11 | 490 | 2.041×10-3 | 2.041×104 | 2245.10 | | (en) | 0.02 | 490 | 2.041×10-3 | 2.041×104 | 408.20 | | (gly) | 1.00 | 490 | 2.041×10-3 | 2.041×104 | 204.10 | |
| **CALCULATIONS:** |
| ***Answer to question 3***  *Decreasing order of crystal splitting energy.*  Glycine > ethylenediamine > NH3 >H2O  Comment: The order above is due to the differences in the binding strengths of the ligands present in the complexes. Glycine has more binding sites than the other complexes thus it has the ability to accommodate more ligands than any of the compounds.  **DISCUSSION:**  All metals have different crystal splitting energies.  The magnitude of this energy depends largely on the nature of the metal and ligands which bond to it.  From the graph, glycine (n=6) (that is 2.041× 1011nm-1) was recorded as the highest energy from the experiment. 2M or 3 M of the NH3 ligand was added in each case except for the experiment n=0 and n=1 where 1M NH3 was added to the complex and this resulted in the low magnitude of the energy recorded.  The least magnitude of the crystal field splitting energy was recorded for n=0 thus this complex is an organic compound which hardly forms coordinate bonds with negatively charged ligands, as a result, their crystal field splitting energy depends solely on their nature (that is their stability).  The crystal field splitting energy of glycine was greater than that of ethylenediamine hence it can be said that the glycine is more stable than the ethylenediamine |
| **PRECAUTIONS:**   1. It was also ensured that the fume chamber was used for the boiling of the solution. 2. It was ensured that the spectrophotometer was zeroed with distilled water before measurements were taken. 3. It was ensured that all volumes were read from the meniscus to reduce error by parallax. |
| **CONCLUSION:**  It can be concluded that, the crystal splitting energy of some copper complexes increased with increasing concentration and number of NH3 ligands present in the complex structure.  Therefore for a group of similar complex species, the crystal field splitting energy depends largely on the concentration and the number of ligands present in the species.  The crystal splitting energy of glycine is greater than that of ethylenediamine; hence glycine is more stable than ethylenediamine.  The crystal field splitting energy depends on both the nature of the complex and the number of ligands present in the complex structure. |
| **REFRENCES:**   1. W. L. Jolly, Modern Inorganic Chemistry, Second Edition, Pp. 357, 468. 2. J.D Lee, Concise Inorganic Chemistry, Fifth Edition, Pp. 202-204, 951. |