Composition of the complex ion by continuous variation biology essay

Transition metals will normally form a complexes or coordination compound. In other words, transition metal ions will form complexes ions by coordination. Those complexes are formed by the coordination of lone pairs of electron from donor is called a ligand to an atom or cation, which is also known as an acceptor which has empty orbital to accommodate them. A cation may form a complex with a neutral molecule. Besides that, an atom may also form a complex. The charge remaining on the central atom or ion when the ligands are removed with their lone pairs is called the oxidation number of the metal in the complex. The number of atom forming coordinate bonds with the central atom or ion is called the coordination number.

Iron is one of the transition metal found in the periodic table. When iron is at the oxidation state of +3, it will form an octahedral complex. Fe3+ tends to be stabilized which is relative to Fe2+ by anionic ligands which have its greatest affinity for oxygen donor include phosphate, tartrate, citrate, oxalate and EDTA. The color of these complexes is normally pale in color due 6A1g ground state and the occurrence of spin-forbidden which is visible to see. Fe3+ in acidic solution consisted of an anions which have low ability of coordination.

All ultraviolet spectrophotometers consist of a photoelectric device which is used to measure the radiant energy. The 4 essential components of the spectrophotometers are a source of radiant energy, the spectrophotometer or monochromator, the absorption-cell assembly and the photometer or detecting device. The spectrophotometers components will permit the selection of radiant energy of the desired wavelength. A quartz prism or a ruled grating is normally employed as the dispersive element in order to separate a continuous spectrum into its constituent wavelengths. T

The optical system of the spectrometer is designed to give different angle of incidence so that the radiant energy of a desired wavelength can be selected to emerge from the exit slit of the spectrometer. The entrance slit is necessary to ensure that the light entering the spectrometers be parallel although at the same time limiting its intensity; the exit slit limits the spectral width of the radiant energy emerging from the spectrophotometer to make this emergent beam as monochromatic. When there is an entrance-slit width is small relative to the exit-slit widths, this will make the spectral range to be narrower but the intensity of the emergent light is weak. By increasing the width of the entrance slit relative to the exit slit will widens the spectral range but the relative intensity at the nominal wavelength is higher. In order to have enough intensity for photometric measurements with prism spectrometers it is necessary to vary the slit width when the wavelength change, this requires a synchronous adjustment of the two slit widths.

Methods/Apparatus:

Result:

X1L (mol)

Absorbance at λ (nm)

Average(nm)

1

2

0. 1

0. 053

0. 060

0. 0565

0. 2

0. 098

0. 103

0. 1005

0. 3

0. 126

0. 131

0. 1285

0. 4

0. 143

0. 147

0. 1450

0. 5

0. 146

0. 152

0. 1490

0. 6

0. 138

0. 144

0. 1410

0. 7

0. 117

0. 123

0. 1200

0. 8

0. 086

0. 092

0. 0890

0. 9

0. 049

0. 036

0. 0425

Graph:

From the graph above, the value of the X is 0. 5 mol.

Calculation:

The number of ligand that is attached to the metal can be calculate as follows:

X: (1-X)

L: M

y = ax

a (1-x)

= x

1-x

= 0. 5

1-0. 5

= 1

To calculate the molar absorptivity of the mixture is as follow:

A= εbc

0. 1490 nm = ε (1 cm) (0. 5 mol)

ε = 0. 298 L mol^{-1} cm^{-1}

Discussion:

Ultraviolet and Visible Spectroscopy

Ultraviolet and visible (UV/Vis) spectroscopy provides information about compounds with conjugated double bonds. It consist just enough right energy to cause an electronic transition which is the promotion of an electron from one orbital to another higher energy. When a molecule absorbs ultraviolet light, a UV spectrum is obtained. However, if the molecule absorbs lower-energy visible light, a visible spectrum is obtained.

Spectrophotometer

The photographic methods of spectrophotometer are not very slow and expensive, but are also limited in accuracy in the measurement of absorption intensity. The accuracy will be in the range of ±2 to ±5%. The modern photoelectric spectrophotometer is known to be accurate within ±0. 2%for the intensity measurement. The photoelectric instruments incorporate one or more photo-cell with certain sensitivity over the whole wavelength range.

Fe3+ complex and salicylic acid

Ammonium Iron (III) sulfate is a double salt in the class of alums. It have the molecular formula of NH4Fe (SO4)2. Fe3+ complexes is a tridentate compound which means that can attach to the central atom. However, salicylic acid is a bidentate compound which means that they are chelate agent which they have two groups that can attach to the central atom. The molecular formula of salicylic acid is C7H6 O3, which the OH group is ortho to the carboxyl group (COOH).

Job's Method

The empirical method shows that only single complex is formed between the reactants. This method also used to determine the complex stoichiometry of the molecular complexes, where hey have the ratio of 1: 1. The more systematic method for the determination of complex stoichiometry is also known as Job's method of continuous variation. This method is used for the photometric analysis of a mixture in the ratio of x: (1-x) volumes of equimolar solutions of concentration M of the two components A and B of the complex. It is assumed that there is no change in the volume when this 2 solution mixed. The equilibrium is expressed by the equation as the following:

αA+ βB= AαBβ= C

K= [A]α[B]β

[C]

where, K= instability constant of the complex C. At experiment condition specified that the equmolar solutions of A and B of concentration M mixed in proportion x: (1-x):

xM=[A]+ α[C]= cA

(1-x) M=[B]+ β [C]= cB

where, quantities in the square brackets = actual concentrations

cA and cB= total concentrations of free plus complexes A and B

It is assumed that all the 3 species which are A, B and C obey the Beer's law at the selected wavelength. The absorbance A of the solution in a 1 cm cell is as follow:

A= εC[C]+ εA[A]+ εB[B]

and Δ A= A- εA[A]- εB[B]= εC[C]

is the difference in absorbance of an actual solution and a mixture when there is no complexing reaction occurs. Δ A is proportional to[C]. The wavelength that is chosen is greatly different from εA and εB.

To make the calculation easier, it can be assume that both εA and εB are 0. A plot of Δ A against x is then curve with a maximum, which is corresponds to:

y = α

(α+ β)

Graph and Results

According to the graph plotted above, the curve with a highest peak can obtain ed. With the highest peak, the mole fraction of ligand and its absorbance can be calculated. The number of the ligand that attached to the metal can be mono-, bis-, or tris (5-fluorosalicylato) iron (III) complexes. In another hand, the complex can be formed together with the monohydroxo and dihydroxo side. Hence, the theoretical value for y may be 1, 2 or 3. But for our case, the y value is 1. The y value of 1 indicated that for the mixture of salicylic acid and ammonium iron (III) sulphate have only 1 ligand that is attached to the iron (III) complex ion and they only have 2 bonds between the ligand and metal.. The ligand ratio may be due to different types of species distribution and electronic absorption band of the complexes in the spectrum. Besides that, by plotting the graph, the value ε can be calculated. The value of ε calculated is 0. 298 L mol^{-1} cm^{-1}. This indicate that the molar absorptivity of the mixture of ammonium (III) sulphate and salicylic acid is 0. 298 L mol^{-1} cm^{-1}.

Device used to determine the spectrum of the salicylic acid and ammonium iron (III) sulphate

The device that can be used to determine the spectrum of the salicylic acid and ammonium iron (III) sulphate is infrared spectroscopy, NMR spectroscopy, mass spectroscopy, ultraviolet and visible spectroscopy.

The infrared spectroscopy can be used to identify the functional groups in the salicylic acid and ammonium iron (III) sulphate. The infrared spectrum can be obtained by passing a beam of infrared radiation through a sample of the complex. Then the detector will generate a plot of percent transmission of radiation versus the wavenumber or wavelength of the radiation that is transmitted.

NMR spectroscopy is used to determine the structure. It can also used to identify the functionality at a specific carbon, how the neighboring carbon appear and how the entire structure of a molecule. When a sample is subjected to a radiofrequency (rf) radiation, the nuclei in the α-spin state can be promoted to the β-spin sate (called ' flipping' the spin). When the nuclei return to their original state, they emit signals whose frequency depends on the difference in energy (ΔE) between the α- and β- spin states. The NMR spectrometer is used to detect the signals and display it as a plot of signal frequency versus intensity is known as an NMR spectrum.

The mass spectroscopy can give a structural information about the salicylic acid and ammonium iron (III) sulphate because the m/z values and relative abundances of the fragments depends on the strength of the molecular ion's bonds and the stability of the fragments. In the mass spectrometry, a small amount of a compound is introduced into an instrument called the mass spectrometer where it is vaporized and then ionized (an electron is removed from each molecule). The common methods that is use to bombard the vaporized molecules with a beam of high energy electrons. The energy of the beam can be varied. When the electron beam hits a molecule, it knocks out an electron producing a molecular ion.

Ultraviolet and visible spectroscopy is used to determine the compounds with conjugated double bonds. When a molecule absorbs light of an appropriate wavelength, an electron can be promoted to a higher energy orbital. It is promoted from the highest occupied molecular (HOMO) to the lowest unoccupied molecular orbital (LUMO). This is called the electron transition and the molecule is said to be in the excited state. The electronic transition with the lowest energy is promotion of a nonbonding electron (n) into a Π antibonding molecular orbital. This is called the n Π8 transition. The higher energy electronic transition is promotion of an electron from a Π bonding molecular orbital into a Π antibonding molecular orbital, a Π Π8 transition. This means that only a compounds with electrons or nonbonding electrons can produce UV/Vis spectra.

Conclusion:

The composition of the iron complex ions in solution can be observed by a spectrophotometer. With this, the complex ion can be determined by method of continuous variation or Job’s method. From this method, the number of ligand that attached to the metal can be determined. The determine value is y= 1. This indicate that there are only 1 ligand is attached to the iron metal and they only have 2 bonds between the ligand and metal. The molar absorptivity (ε) of the mixture of ammonium iron (III) sulphate and salicylic acid is 0. 298 L mol^{-1} cm^{-1}.