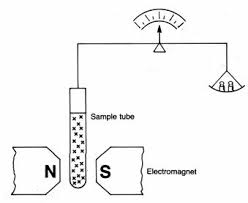
**Magnetic properties of transition metal complex**

**Abstract**

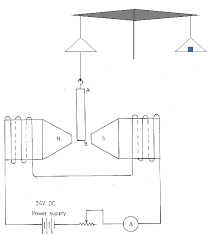
In this abstract, the magnetic characteristics of transition metal complexes are briefly reviewed, along with the Spin-Only formula, Louis Georges Gouy's technique, and orbital contributions to magnetic moment. It also covers kinetic and thermodynamic features, including formation constants, stability-affecting variables, and thermodynamic and kinetic stability. It also refers to Job's approach of figuring out difficult composition.

The Gouy balance (1), invented by Louis Georges Gouy, is a device for measuring the magnetic susceptibility of a sample.

**Procedure**

 A strong magnetic field can cause a sample to attract or repel, and the Gouy balance is used to determine the apparent change in mass (2). Some commercially available balances contain a port at their base to permit this measurement. The Gouy balance is made up of a working balance and a long cylindrical test sample suspended from it. The sample, whether solid or liquid, is usually kept in a cylindrical container, such as a test tube. To achieve homogeneity across the sample, solid substances are frequently crushed into fine powder. A thread or string is used to hang the sample between the magnetic poles (3).

## Concept

 The magnetic force acting on the sample is what causes the mass difference that was noticed between the two balance readings. A gradient between a strong and weak magnetic field produces this force. The apparent mass difference (mb - ma) is positive when a sample contains a paramagnetic chemical because it is drawn to the magnetic field. If the sample is marginally repulsed by the applied magnetic field, there may be either no discernible change in weight or a negative change in the case of diamagnetic substances. For paramagnetic samples, a positive magnetic susceptibility is produced when the magnetic induction's strength is greater than the applied field's. A diamagnetic material has a significantly weaker magnetic induction and a correspondingly negative magnetic susceptibility as compared to the applied field (4). The following mathematical equation relates the apparent change in mass to the volume susceptibility of the sample:

**Force = (mb – ma)g =  (K2 – K1)AH2**

* mb – ma = apparent difference in mass
* g = gravitational acceleration
* K1 = volume susceptibility of sample
* K2 = volume susceptibility of medium, usually air and of negligible value
* H = applied magnetic field
* A = area of the sample tube

## Instrument

The complete balance-magnet assembly is often housed in a glass box in practical devices to prevent the impact of air currents on weight measurements. Additionally, the sample can be put within a thermostat to allow for readings at various temperatures. The Gouy balance is a stationary device that is consistently set up on a bench since it requires a substantial and potent electromagnet (5). In a controlled setting with little vibrations and disturbances, it is frequently placed on a marble balancing table. An electromagnet that is attached to a power source is frequently employed as the stationary magnet in a Gouy balance since measurements both with and without the applied magnetic field are necessary during the process.

**Complexes of transition metal ions**

The effective magnetic moment of a combination containing a transition metal ion with one or more unpaired electrons is controlled by the combined orbital and spin angular momentum of these unpaired electrons, indicated as L and S, respectively. In this case, "total" refers to the vector sum of these angular momenta. Assuming that the electronic states of the metal ions are governed by Russell-Saunders coupling and ignoring spin-orbit coupling, the magnetic moment can be written as follows: (6).

\mu_{\text{eff}} = \sqrt{\vec{L}(\vec{L}+1)+ 4\vec{S}(\vec{S}+1)} \mu_B

### Spin-Only Formula and Orbital Contribution To Magnetic Moment:

An electron in a degenerate set of orbitals receives orbital angular momentum when it rotates into another orbital. Some rotations, however, may be impossible in complexes with great symmetry. When this happens, the orbital angular momentum is said to be "quenched," generating either a value less than expected (partial quenching) or zero (complete quenching).Certain situations cause total quenching. Because of symmetry, an electron within a degenerate pair of dx2-y2 or dz2 orbitals cannot rotate into the other orbital. Because of the lack of rotational mobility in these cases, the orbital angular momentum is entirely quenched (7).

**Quenched orbital angular momentum**

|  |  |  |
| --- | --- | --- |
| dn | Octahedral | Tetrahedral |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | High spin | Low spin |  |
| d1 |  |  |  | e1 |
| d2 |  |  |  | e2 |
| d3 | t2g3 |  |  |  |
| d4 |  | t2g3eg1 |  |  |
| d5 |  | t2g3eg2 |  |  |
| d6 |  |  | t2g6 | e3t23 |
| d7 |  |  | t2g6eg1 | e4t23 |
| d8 | t2g6eg2 |  |  |  |
| d9 | t2g6eg3 |  |  |  |

t2g, t2 = (dxy, dxz, dyz). eg, e = (dx2–y2, dz2).

When the orbital angular momentum is completely quenched, the only factor responsible for a compound's paramagnetic behaviour is the electron spin. The spin-only formula is established when the total spin angular momentum is equal to half the number of unpaired electrons. For estimating the magnetic moment, the spin-only formula, written as

,**\mu_{\text{eff}}= \sqrt{n(n+2)} \mu_B**

The quantity n here denotes the quantity of unpaired electrons. The spin-only formula, which provides a reliable estimation of their magnetic characteristics, is particularly applicable to high-spin complexes of first-row transition metals.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ion | Ti3+ | V4+ | Cu2+ | V3+ | Ni2+ | V2+ | Cr2+ | Co2+ | Mn4+ | Cr2+ | Fe2+ | Mn2+ | Fe3+ |
| No.of.unpaired electrons | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 |
| Spin only/μB | 1.73 |  |  | 2.83 |  | 3.87 |  |  |  | 4.90 |  |  | 5.97 |
| observed | 1.73 | 1.68-1.78 | 1.70-2.20 | 2.75-2.85 | 2.8-3.5 | 3.80-3.90 | 3.70-3.90 | 5.3-5.0 | 3.80-4.0 | 4.75-4.90 | 5.1-5.7 | 5.65-6.1 | 5.7-6.0 |

The orbital angular momentum or spin-orbit coupling was ignored, which is why the deviations from the spin-only formula were so minor. Departures from the spin-only formula can differ from octahedral complexes of the same metal ion in some cases, such as tetrahedral complexes with d3, d4, d8 and electron configurations. This is owing to the less effective "quenching" of the orbital contribution in tetrahedral complexes, which results in a greater impact of orbital angular momentum on magnetic properties. The changes from the spin-only formula can also be attributed to spin-orbit coupling, which accounts for the interaction between electron spin and orbital motion.

**Example**

**At 80 K and 300 K, the magnetic moments of (Et4N)2[NiCl4] are 3.25 B.M. and 3.89 B.M.** **respectively.**

A Ni2+ ion with a d8 electron configuration is present in the combination. The formula suggests a 4-coordinate complex, which we can suppose is tetrahedral with a d electron configuration ofe4 t2g The spin-only magnetic moment is equal to 2.83 B.M.

Because the formula predicts a tetrahedral coordination geometry, the idea of the complex being square-planar was neglected.The possibility of the complex being square-planar was ignored because the formula suggests a tetrahedral coordination geometry.Considering the free ion Russell-Saunders ground term, which is 3F with L=3 and S=1, the lowest energy T term is expected to be present in a tetrahedral field. Hence, the resultant magnetic moment is expected to be temperature-dependent and have a direct orbital contribution.

The observed magnetic moments may differ significantly from the calculated spin-onlymagneticmoment. The value of µS+L can be calculated as: µS+L = √[4S(S+1)+L(L+1)] = √[8+12] = √20 = 4.47 B.M.

Using the spin-only formula, µs = √[n(n+2)] = √8 = 2.8 B.M. (8)

**Given that the spin-only magnetic moment for the complex [Cr(en)3]Cl3**

The spin-only magnetic moment is given by quantum mechanics as μ = √[n(n+2)] BM =

μ = √15 = 3.87 BM

**The Observed Magnetic Moment of [Mn(NCS)6]4- Is 6.06 B.M. Predict The Electronic Configurations.**

Mn in this complex is Mn(II) d5. There are two possibilities of an electronic configuration for this octahedral species, namely low-spin t2g5 with one unpair electron & t2g3eg2 with five unpaid electrons. The observed magnetic moment is close to the spin-only value

Therefore, the configuration should be t t2g3eg2 (high spin)

**Metal Complexes: Thermodynamic and Kinetic Aspect**

A metal complex is referred to as a stable complex, indicating its presence and the ability to be stored for an extended period under appropriate conditions. It is important to note that the stability of a complex can vary depending on the reagents involved. While a complex may exhibit stability towards one reagent, it may readily decompose in the presence of another reagent. Additionally, the stability of a complex can be influenced by external factors such as heat or light exposure..

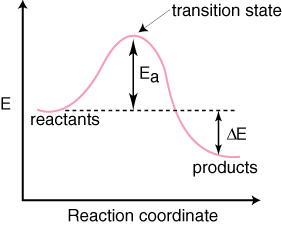
* 1. **Thermodynamic Stability**
  2. **Kinetic Stability**

When studying the formation of complexes in a solution, two types of stability can be observed: (9)

**Thermodynamic Stability:** This refers to the equilibrium between the complex and its constituent species. A thermodynamically stable complex possesses a favorable formation constant or equilibrium constant, indicating that the complex formation is preferred over the dissociation of the complex into its individual components.

**Kinetic Stability:** This pertains to the rate of formation and decomposition of the complex. A kinetically stable complex exhibits slow rates of decomposition, suggesting that the complex remains intact for an extended period of time.

Both thermodynamic and kinetic stability play significant roles in determining the overall stability of a complex in solution.

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**Both the overall formation constant and stepwise formation constant**

Jannik Bjerrum presented a generic approach for computing stability constants of metal-ammine complexes in 1941, about 50 years after Alfred Werner established suitable structures for coordination complexes. Beck and Nagypál listed the reasons for this delay. The concentrations of hydrogen ions in solution were determined using Bjerrum's approach with a freshly made glass electrode and pH metre.

Bjerrum understood that an acid-base balance was required to create a metal-ligand combination. The ligand, L, was being competed for by the metal ion Mn+ and the hydrogen ion H+. As a result, two simultaneous equilibria were taken into account. For the sake of brevity, the following discussion excludes electrical charges. the two following equilibriums:

H + L  HL

M + L  ML

The majority of the time, a substitution process takes place when a metal ion, M, and a ligand, L, come together to create a complex. For instance, metal ions are frequently found as aqua-ions in aqueous solutions. As a result, the following reaction can be used to depict the production of the first complex:

\mathrm{[M(H_{2}O)_n] + L \leftrightharpoons [M(H_{2}O)_{n-1}L] + H_{2}O}

\beta'=\mathrm{\frac{[M(H_2O)_{n-1}L] [H_2O]} {[M(H_2O)_n] [L] }}

The concentration of the ligand L is denoted by the notation [L], and similarly, the sentences contained in square brackets denote concentrations. To simplify the formula, constant terms can be removed. In the case of metal complexes, the number of water molecules bound to each metal ion remains constant. Furthermore, the concentration of water in diluted solutions can be thought of as effectively constant. As a result, the phrase can be summarised as follows:.

\beta =\mathrm{\frac{[ML] } {[M] [L] }}.

Following this simplification, a general definition can be developed. The equilibrium for the production of a metal-ligand complex is as follows:

It is emphasised in laboratory courses that "stability of a complex in solution" refers to the degree of connection between the two species involved in the equilibrium state. A higher degree of connection indicates that the chemical is more stable. The value of the equilibrium constant for the association, known as the stability or formation constant, expresses the stability quantitatively. As a result, if we have a reaction of the following type:

M    +  4L    ⇄     ML  
  
In this case, when the stability constant grows, the proportion of ML4 in the solution increases. Free metal ions are rarely seen in solution because the metal ion M is normally surrounded by solvent molecules that compete with and gradually replace ligand molecules L. To make the study easier, we frequently ignore the influence of solvent molecules and represent the four stability constants as follows:

1. M + L ⇄ ML               K1 = [ML [L]] / [M]   
2. ML + L ⇄ ML2           K2 = [ML2] / [ML] [L]   
3. ML2  + L ⇄ ML3         K3 = [ML3] / [ML2] [L]   
4. ML3  + L ⇄ ML4         K4 = [ML4] / [ML3] [L] 

where the "stepwise stability constants" K1, K2, etc. A different way to express the "Overall Stability Constant," represented by βn is as follows: (10)

M   +  4L   ⇄   ML4           β4 = [ML4]/ [M] [L]4

***Relationship between The stepwise and overall stability constants are as follows:***

β4=K1.K2.K3.K4 or more generally,  
βn=K1.K2.K3.K4--------------Kn

Or

This equation evident that overall stability constants is equal to stepwise stability constants.

**Consider the four steps involved in the formation of the cuprammonium ion Cu(NH3)42+:**

**STEP 1:**     Cu2++NH3 ⇄  Cu(NH3)2+   
where K1   =     [Cu(NH3)2+]

                          [Cu2+][NH3]  
**STEP 2:**     Cu(NH3)2+ + NH3 ⇄  Cu(NH3)2+2  
where K2  =       [Cu(NH3)22+]  
                        [Cu(NH3)2+][NH3]  
**STEP 3:**     Cu(NH3)22+ + NH3  ⇄  Cu(NH3)32+  
where K3  =       [Cu(NH3)32+]  
                       [Cu(NH3)22+][NH3]  
**STEP 4:**     Cu(NH3)32+ + NH3 ⇄  Cu(NH3)42+  
where K4  =       [Cu(NH3)42+]  
                        [Cu(NH3)32+][NH3]  
  
where the {K} constants are the stepwise stability constants.  
In terms of overall stability constant:  
  
β4   =     [Cu(NH3)42+]  
              [Cu2+][NH3]4

Hence

β4=K1.K2.K3.K4

The four ammine groups added to copper show the same trend as the bulk of formation constants, in that the subsequent stability constants decrease. In this case, the four variables are:

logK1 =4.0, logK2 =3.2, logK3 =2.7, logK4 =2.0 or logβ4 =11.9

The stability of complexes is impacted by a variety of elements, all of which play an important part in determining their overall stability. The key elements influencing complex stability can be summarised as follows:

1. Charge carried by the metal ion: The charge carried by the metal ion has a substantial impact on complex stability. Complexes having larger charges on the metal ion are more stable in general.
2. Complex stability is also affected by the primary quantum number of the metal ion's outermost electron shell. Complexes with larger primary quantum numbers are frequently more stable.
3. The type of the ligands involved in complex formation is an important element. Different ligands have unique qualities such as size, shape, and electrical properties, which affect the stability of the resultant complexes.
4. Chelation: Chelation is the creation of a cyclic structure when a ligand forms numerous bonds with a metal ion. Complexes containing chelating ligands have higher stability due to increased coordination number and structural integrity.
5. Macrocyclic ligands are compounds with enormous ring configurations that can enclose metal ions. These ligands' distinct size and shape lead to the development of highly stable complexes.
6. Hardness and softness are terms that refer to the electrical characteristics of both the metal ion and the ligands. It is critical to match the hardness or softness of the metal ion and ligands in order to achieve maximum complex stability.
7. Environmental factors: Environmental circumstances such as pH, temperature, and solvent can affect the stability of complexes. Changes in these conditions can have an effect on the equilibrium between free metal ions and complexes, affecting their stability.
8. Researchers can obtain a better knowledge of complex stability and make more informed decisions about the design and application of coordination molecules by taking these considerations into account

**1. Charge on the metal ion:**

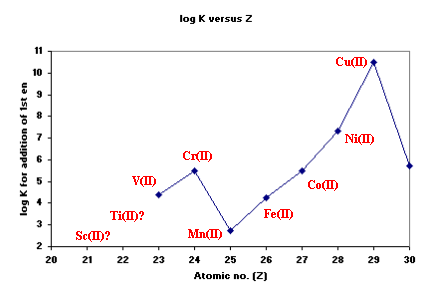
It is possible to understand how this affects the stability of complexes by taking into account crystal field theory. The overall stability of the complex is impacted by the degree of crystal field splitting in the context of a particular ligand, which is directly proportional to the size of the metal ion's charge.,

**Ions                            Ligands                                 CFSE (∆oin cm-1)**

     V2+                              6H2O                                      12601

            V3+                              6H2O                                      17702

# Irving–Williams series (11)

The Irving-Williams Series, discovered in 1953 by Harry Irving and Robert Williams, illustrates the trend in relative stabilities of complexes produced by divalent first-row transition metal ions. According to their observations, the stability of these complexes often rises over time, peaking at copper. The trend can be summarised as follows: Mn(II) Fe(II) Co(II) Ni(II) Cu(II) > Zn(II

## Explanation

The Irving-Williams Series is often justified by three explanations:

The steady drop in ionic radius from Mn(II) to Zn(II) that follows the usual periodic pattern can be attributed to the trend. This reduction in size usually results in an increase in complex stability.The Crystal Field Stabilisation Energy (CFSE) increases from Mn(II) to Ni(II), reaching a peak at Ni(II). The rise in CFSE leads to the complexes' increased stability. Zn(II) has a CFSE of zero.Although Cu(II) has a lower CFSE than Ni(II), octahedral Cu(II) complexes benefit from the Jahn-Teller effect, which adds stability to these complexes.However, none of these hypotheses entirely explain the Irving-Williams Series' predictive effectiveness in determining the relative stabilities of transition metal complexes. Recent research on metal-thiolate complexes suggests that the observed series may be influenced by a combination of covalent and electrostatic interactions in metal-ligand binding energies.Notably, the Crystal Field Stabilisation Energy (CFSE) values for octahedral complexes of first-row transition metals such as iron, cobalt, and nickel (oct) are 0.4 (4 Dq) for iron, 0.8 (8 Dq) for cobalt, and 1.2 (12 Dq) for nickel. In the absence of crystal field effects, when stability constants are quantitatively modified to account for these CFSE values, they coincide with the predicted trend between manganese and zinc. The acceptance of crystal field theory, the first theory to adequately explain the thermodynamic, spectroscopic, and magnetic properties of transition metal complexes and the foundation for ligand field theory, was greatly influenced by this alignment.

**2. Principal quantum number.**

The Crystal Field Stabilisation Energy (CFSE) of metal ions can vary in magnitude even when they have the same charge due to changes in their primary quantum numbers, which in turn impacts the stability of complexes. This can be demonstrated by thinking about the following illustration:,

**Principal Q.No.        Ions                     Ligands                                 CFSE(∆oin cm-1)**

           d6                  d6-Co3+                       6H2O                                      18601

           d6                 d6-Rh3      6H2O                                      20610

**3.  Nature of ligands:**

Complexes' CFSE and stability can be affected by a variety of ligand characteristics, such as size, charge, dipole moment, polarizability, and -bonding capability. These characteristics' effects can be summed up as follows:

Smaller ligands are found to be closer to the metal ion, which causes more crystal field splitting and stronger interactions.

The overall stability of the complex is impacted by the increased magnitude of crystal field splitting that results from an increase in the charge of anionic ligands.

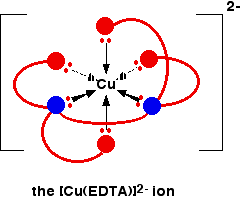
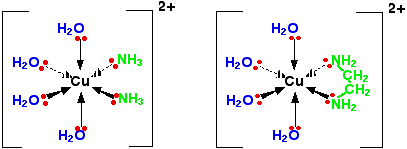
To sum up, ligand size and charge are key factors in CFSE and complex stability, with smaller ligands and higher charge on anionic ligands contributing to increased crystal field splitting..

1. **Chelation:**

**The larger the number of the chelate ring in complex, greater is its stability.**

**The stability of complex is also depends on number of atom present in a ring.**

**It has been proved that the most stable chelate are 5 and 6 – member one. It is found that 5-memerd chelate is frequently more stable than 6-memmberd ring. On the other hand 6-memberd chelates are more stable than 5-memberd chelates of heterocyclic ligand. For example acetyl acetone complexes of the metal ions are more stable than the corresponding ethylene diamine complexes which contain only 5-memberd chelate complex ring.**



Chelation upsurges stability. This is because the entropy factor is promising in case of chelate complexes

For example [Cd(en)2]2+ is more stable than [Cd(MeNH2)4]2+ since in the former there is chelation.

**5.  Macro cyclic ligands:**

The "macrocyclic effect" is the name given to the increased stability seen in complexes comprising macrocyclic ligands. Entropy and enthalpy considerations both contribute to this effect. Macrocyclic ligands have distinct cavities with predetermined diameters, which enables them to form strong complexes with metal ions of the right size.

A good illustration is the fact that the ligand 18-crown-6 forms more complexes with potassium ions than sodium ions. This is due to the potassium ion's good fit inside the cavity of the 18-crown-6 ligand, which increases the stability of the complex

.**6. Hardness and softness:**

The hardness and softness of the metal and ligands have an impact on complex stability as well. According to the HSAB principle, soft acids favour soft bases and hard acids prefer hard bases.

For example, Ni2+ is a hard acid and hence it forms stable complex with NH2 and not with soft ligand PH3.But Pd2+ being soft acid forms stable complex with PH3 rather than with NH2.

1. **Surrounding conditions:**

Even though the above factors outline the stability of complexes, many complexes which are stable under particular conditions may not be stable under some other conditions.

For example [Co(NH3)6]3+  is unstable in an acidic solution but is stable in water under neutral conditions.

[Co(NH3)6]3+ + 6H3O+ → [Co(H2O)6]3+ + 6NH4+

The question "Under what conditions?" must therefore always be asked when someone claims that a complex is stable. Heat, light, acidity, or basicity could be present.

**Determination of Composition of Complexes Using Job's Method**

The mole-ratio method is an alternate way for figuring out the stoichiometry of metal-ligand complexes. This approach involves controlling the amount of one reactant, usually the metal, while varying the amount of the other, usually the ligand. The solution's absorbance is then determined at the wavelength at which the metal-ligand complex absorbs.The findings achieved with the mole-ratio approach are shown in the examples below:The absorbance is measured at a wavelength where only the complex absorbs, as shown in

(a) the mole-ratio plot for the creation of a 1:1 complex.

(b) The mole-ratio plot of a 1:2 complex, which absorbs at the chosen wavelength for all three species—the metal, the ligand, and the complex.

(c) A mole-ratio plot showing the production of ML andML2.

**Overview**

In this experiment, a series of mixtures consisting of iron(III) and 5-sulfosalicylic acid (SSA) solutions were prepared. The mixtures were systematically varied from one containing a small amount of iron and a large amount of SSA to one containing a large amount of iron and a small amount of SSA. The % Transmittance of each mixture was measured using a Spectronic 20 spectrophotometer, and the absorbance of each solution was calculated based on the % Transmittance.

Using the calculated absorbance values, a graph was plotted by plotting the absorbances against the mole fraction of SSA for each solution. The resulting graph exhibits a maximum point, indicating the molar ratio at which the reaction between iron(III) and SSA occurs to the greatest extent.

In chemical reactions, substances react with each other in a fixed and definite mole ratio, which is referred to as the stoichiometry of the reaction. Among the systematically-varied mixtures, only one mixture reflects the correct mole ratio at which the substances react to the maximum extent possible. This can be observed visually by the intensity of the color of the product formed, with the mixture displaying the deepest purple color indicating the highest amount of product formed due to the maximum extent of the reaction.

**Calculations**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test tube | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| %T | 61.0% | 39.4% | 27.7% | 22.1% | 19.9% | 22.0% | 27.9% | 40.1% | 60.5% |

Suppose the data had been recorded for the experiment 19.9%.  % Transmittance of Solutio (12)

**A. Calculation of Absorbance of Solution in Test tube #3**

The absorbance of a colored solution is directly related to the concentration of the colored species present in the solution. The absorbance can be calculated using the measured % Transmittance according to the following derivation:

Absorbance = -log (%T/100) = log (100/%T) = log (100) - log (%T) = 2 - log(%T).

In the case of solution #3, the % Transmittance was determined to be 27.7%. To calculate the corresponding absorbance, we substitute this value into the equation:

Absorbance = 2 - log(%T) = 2 - log(27.7%) = 2 - 1.442 = 0.558.

It is important to note that when performing this calculation, one should be cautious with the use of calculators. Different calculators may require different keystrokes for computing logarithmic functions. Additionally, the resulting absorbance values should fall within the range of 0 to 2. If an absorbance value outside of this range is obtained, it indicates an error in calculator usage.

**B. Calculation of the moles of Fe+3 is Test Tube #3**

To calculate the number of moles of iron(III) present in Test Tube #3, we need the volume of the stock Fe(III) solution used and the concentration of the Fe(III) stock solution.

According to the information provided, the volume of iron(III) stock solution used in Test Tube #3 is 3.00 mL. The concentration of the iron(III) stock solution is given as 1.65 × 10^(-3) M (moles of Fe^(3+) per liter).

To calculate the number of moles of Fe(III) in Test Tube #3, we can use the formula:

Number of moles = Concentration × Volume

Converting the volume from milliliters to liters:

Volume = 3.00 mL = 3.00 × 10^(-3) L

Plugging in the values into the formula:

Number of moles = (1.65 × 10^(-3) M) × (3.00 × 10^(-3) L) = 4.95 × 10^(-6) moles of Fe(III)

Therefore, the number of moles of Fe(III) in Test Tube #3 is 4.95 × 10^(-6) moles.

,

**C. Calculation of the moles of SSA in Test Tube #3**

To calculate the number of moles of SSA (5-sulfosalicylic acid) in Test Tube #3, we need the volume of the SSA solution used and the concentration of the stock SSA solution.

According to the information provided, the volume of SSA solution used in Test Tube #3 is 7.00 mL. The concentration of the stock SSA solution is given as 1.71 × 10^(-3) M (moles of SSA per liter).

To calculate the number of moles of SSA in Test Tube #3, we can use the formula:

Number of moles = Concentration × Volume

Converting the volume from milliliters to liters:

Volume = 7.00 mL = 7.00 × 10^(-3) L

Plugging in the values into the formula:

Number of moles = (1.71 × 10^(-3) M) × (7.00 × 10^(-3) L) = 1.197 × 10^(-5) moles of SSA

Therefore, the number of moles of SSA in Test Tube #3 is 1.197 × 10^(-5) moles.

**D. Calculation of mole fraction of SSA in Test Tube #3**

The number of moles present of the component of interest divided by the sum of all the other components' moles in a mixture is known as the mole fraction. 4.95 10-6 moles of Fe3+ and 1.20 10-5 moles of SSA are present in the combination.

**E. Calculation of mole fraction Fe(III) in Test Tube #3**

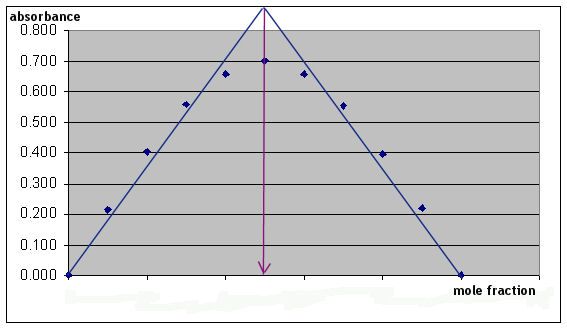
This calculation is based on the same data as in Part D above, only in terms of Fe(III) rather than SSA: (13)

***X*Fe = (1 - *X*SSA) = (1- 0.708) = 0.292.**

**A. Summary of Results**

The table only lists your totals for Mole Fraction and Absorbance for each of your solutions. The computations are carried out exactly as shown before, with the exception that the appropriate volumes of Fe and SSA are used in place of the individual answers..

**B. Results from Graph**

When you plot your nine data points, you should notice that there are a set of ascending data points and a set of falling data points when you make your graph. You should draw two lines on your graph: one for the increasing data points and one for the decreasing data points, as well as a smooth curve through the data points. The junction of these two lines indicates the biggest point on your graph (according to the mole fraction, horizontal scale).

Here's a basic representation of the form. (14)

# Works Cited

1. *Gouy’s Tube.* **Sella, Andrea.** 2010, Royal Society of Chemistry,.

2. *A permanent magnet Gouy balance.* **Saunderson, A.** 1968, Phys. Educ., Vol. 3, p. 272. DOI 10.1088/0031-9120/3/5/007.

3. *Magnetic susceptibility: A physical chemistry laboratory experiment.* **Stafford, Lewis J. Brubacher and Fred E.** 11, 1962, J. Chem. Educ. , Vol. 39, p. 574. https://doi.org/10.1021%2Fed039p574.

4. **Earnshaw, Alan.** *Introduction to Magnetochemistry.* s.l. : Academic Press., 1968. 89.

5. **Liang, S.H., Harrison, B.H. and Pagotto, J.G.** *Determination of the Impregnant Concentrations on ASC Type Charcoal﻿ .* s.l. : Defence Research Establishment Ottawa., 1987.

6. *Magnetic susceptibility: A physical chemistry laboratory experiment.* **Brubacher, L. and Stafford, F.** 11, 1962, Journal of Chemical Education , Vol. 39, p. 574. https://dx.doi.org/10.1021%2Fed039p574.

7. s.l. : en.wikipedia.org.

8. s.l. : https://www.coursehero.com/.

9. s.l. : studyres.com.

10. s.l. : https://www.astrazeneca.com/our-company/our-people/esben-jannik-bjerrum.html.

11. s.l. : https://en.wikipedia.org/wiki/Irving%E2%80%93Williams\_series.

12. *Theoretical and experimental study of the mechanisms of phosphate removal in the system containing Fe(III)-ions.* Environmental Science and Pollution Research. https://link.springer.com/article/10.1007/s11356-016-7672-3.

13. s.l. : https://chem.libretexts.org/Bookshelves/Analytical\_Chemistry/Instrumental\_Analysis\_(LibreTexts)/13%3A\_Introduction\_to\_Ultraviolet\_Visible\_Absorption\_Spectrometry/13.01%3A\_Transmittance\_and\_Absorbance.

14. *Can Terahertz Time-domain Spectroscopy Detect an Extended Hydration Layer around Peptides?* **Falconer, Robert J.** s.l. : Conference: International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz) 2013At: Mainz Germany.