❖ Gouy's Method for Determination of Magnetic Susceptibility

The simplest method used for measuring the magnetic susceptibilities of transition metal complexes was proposed by a French physicist, named Louis Georges Gouy. In 1889, He obtained a mathematical expression revealing that the force is actually proportional to volume susceptibility (K) or the interaction of material in a uniform external magnetic field. From this derivation, Gouy suggested that the balance measurements taken for tubes of material suspended in a magnetic field could evaluate the expression for volume susceptibility. Though Gouy never tested his scientific proposal, this inexpensive and simple technique would become a blueprint of the Gouy balance; and therefore, for measuring magnetic susceptibilities.

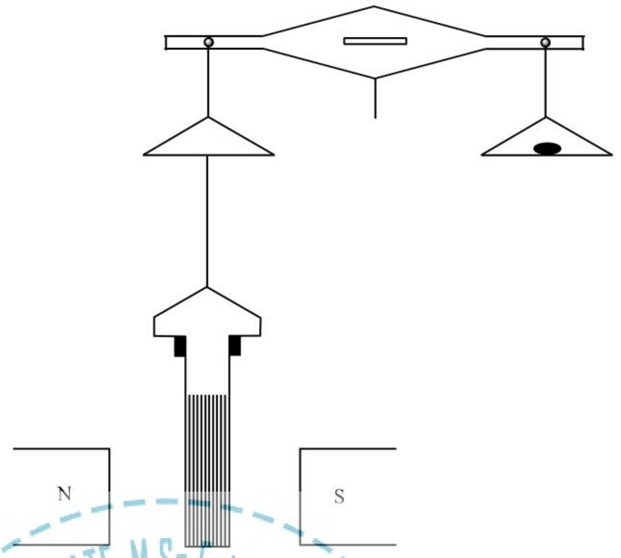

Figure 8. The schematics of Gouy balance.

The determination of a magnetic susceptibility depends on the measurement of B/H. From the classical description of magnetism, Lenz's law can be stated as:

$$\frac{B}{H} = 1 + 4\pi K \tag{23}$$

where B/H is called the magnetic permeability of the material and K is the magnetic susceptibility per unit volume (I/H). The Gouy's method includes the measurement of force on the sample by the externally applied magnetic field and depends upon the tendency of the sample to align itself in high or low magnetic field strength. The force at any given point of the sample (say dx) is given by:

$$dF = \mu^{\circ} H\, K dV\, \frac{dH}{dx} \tag{24}$$

Where μ° symbolizes the permeability of the vacuum (value is 1 when using c.g.s. system of units), dV is the volume of the sample at point dx, H is the magnitude of the magnetic field at point dx and K represents the magnetic susceptibility per unit volume. The Gouy tube, packed uniformly with the sample is placed in the magnetic field such that each end of the glass tube experiences a constant field strength. In order to achieve this situation, the Gouy's tube must be packed to a certain height like 10 or 15 cm, and the tube is then hanged between the electromagnetic poles in such a way that the bottom of the sample lies in the center of the magnetic field (an area where a uniform field strength can be easily achieved); while the top of the sample is out of the field ($H = 0$). Now, the total magnitude of the force acting on the sample can be calculated just by integrating the equation (24).

$$F = \mu^{\circ} A\, K \left[\frac{H^2}{2}\right]_0^H \tag{25}$$

$$F = \frac{\mu^{\circ} A\, K H^2}{2} \tag{26}$$

Where *A* is the area of cross-section of the sample. The force can easily be measured by the apparent change in mass when the external magnetic field is switched on.

$$F = g\Delta w \tag{27}$$

Where *g* is the acceleration due to gravity and Δ*w* is the apparent deviation in mass. From equation (26) and equation (27), we get:

$$g\Delta w = \frac{\mu^{\circ} A\, K H^2}{2} \tag{28}$$

It is also worthy to mention that some correction must be made for the tube because it possesses its own magnetic properties due to air-filled within the tube, and the nature of its construction materials. Therefore, equation (28) takes the form:

$$g\Delta w' = \frac{\mu^{\circ} A\, (K - K')\, H^2}{2} \tag{29}$$

Where $\Delta w' = \Delta w + \delta$, δ is a constant allowing for the magnetic properties of the empty tube, *K′* is the volume susceptibility of the replaced air. This gives:

$$K = \frac{2g\Delta w'}{\mu^{\circ} A\, H^2} + K' \tag{30}$$

Converting from volume susceptibility (*K*) to mass susceptibility (χ) leads to:

$$\chi = \frac{K}{\rho} = \frac{KV}{W} = \frac{2g\Delta w' V}{\mu^{\circ} A\, H^2 W} + \frac{K'V}{W} \tag{31}$$

$$\chi = \frac{\beta \Delta w'}{W} + \frac{K'V}{W} \tag{32}$$

$$\chi = \frac{(\alpha + \beta \Delta w')}{W} \tag{33}$$

Where $\alpha = K'V$ is a correction constant incorporated for the air replaced by the sample, $\beta = (2gV)/(\mu^{\circ} A H^2)$ is also a constant which depends upon the strength of the magnetic field and *W* is the weight of the sample under consideration. In order to measure the mass susceptibility a sample more accurately, the predetermine of α, β and δ is necessary. Therefore, the dependence of these constants on the magnetic field strength, the amount of sample put in the tube and the tube itself emphasize on the fact that each analyst must find their value for every new configuration.

Determination of the constants can be carried out by selecting a tube and a small nichrome-wire to make an assembly which will allow the tube to be hanged from the analytical balance so that the bottom of the tube is aligned halfway between the mutually-facing poles of the electromagnets used, and sample's top is above the magnet and thus subject to a zero-field strength.

i) Calculation of δ: Adjust the zero on the Gouy's balance, then suspend the empty tube from the balance and measure its weight (W_1). Now turn on the electromagnets to desired magnetic field strength and reweigh the tube (W_2). The force on the Gouy's tube, δ, is thus $\delta = W_2 - W_1$. The value will be negative because the tubes are generally diamagnetic and are pushed out of the magnetic field.

ii) Calculation of α: Fill the water in Gouy's tube to the required marking and weigh it, this will give the value of W_3. Now considering the density of water at this temperature as 1.00 g cm^{-3}, this volume of water would be equal to the volume of the sample. Hence, $V = (W_3 - W_1)/1.00$, where the changes in weight should be expressed in grams. Now, $\alpha = K'V$ or $\alpha = 0.029 \times (W_3 - W_1)$ in 10^{-6} c.g.s. units, where 0.029 is the volume susceptibility of the air.

ii) Calculation of β: The measurement of *β* requires a standard compound whose magnetic properties are already known. The most commonly used calibrants are $[Ni(en)_3]S_2O_3$ and $Hg[Co(SCN)_4]$. Now because of fact that the magnetic properties are usually temperature-dependent, the susceptibility of the calibrant must be determined at a temperature exactly similar to what is required for the sample. Record the temperature, T_1, and then fill the tube to the required height with the calibrant and weigh it with the magnetic field off (W_4) and on (W_5). For $[Ni(en)_3]S_2O_3$, use $\chi = 3172/T$ in 10^{-6} c.g.s units; while for $HgCo(SCN)_4$ the $\chi = 4985/(T+10)$ in 10^{-6} in c.g.s unit can be used at temperature T. Using this χ then $\beta = (\chi W - \alpha)/\Delta w'$, where $\Delta w' = (W_5 - W_4) - \delta$ in mg and $W = (W_4 - W_1)$ in grams.

Home

CLASSES

NET-JRF, IIT-GATE, M.Sc Entrance & IIT-JAM

Want to study chemistry for CSIR UGC – NET JRF, IIT-GATE, M.Sc Entrance, IIT-JAM, UPSC, ISRO, IISc, TIFR, DRDO, BARC, JEST, GRE, Ph.D Entrance or any other competitive examination where chemistry is a paper ?

READ MORE

BOOKS

Publications

Are you interested in books (Print and Ebook) published by Dalal Institute ?

READ MORE

VIDEOS

Video Lectures

Want video lectures in chemistry for CSIR UGC – NET JRF, IIT-GATE, M.Sc Entrance, IIT-JAM, UPSC, ISRO, IISc, TIFR, DRDO, BARC, JEST, GRE, Ph.D Entrance or any other competitive examination where chemistry is a paper ?

READ MORE

Home: https://www.dalalinstitute.com/
Classes: https://www.dalalinstitute.com/classes/
Books: https://www.dalalinstitute.com/books/
Videos: https://www.dalalinstitute.com/videos/
Location: https://www.dalalinstitute.com/location/
Contact Us: https://www.dalalinstitute.com/contact-us/
About Us: https://www.dalalinstitute.com/about-us/

Postgraduate Level Classes (NET-JRF & IIT-GATE)

Admission

Regular Program | Distance Learning

Test Series | Result

Undergraduate Level Classes (M.Sc Entrance & IIT-JAM)

Admission

Regular Program | Distance Learning

Test Series | Result

A Textbook of Inorganic Chemistry – Volume 1

"A Textbook of Inorganic Chemistry – Volume 1 by Mandeep Dalal" is now available globally; including India, America and most of the European continent. Please ask at your local bookshop or get it online here.

READ MORE

Join the revolution by becoming a part of our community and get all of the member benefits like downloading any PDF document for your personal preview.

Sign Up

International Edition

A TEXTBOOK OF INORGANIC CHEMISTRY

Volume I

MANDEEP DALAL

First Edition

DALAL INSTITUTE

Table of Contents

Mandeep Dalal
(M.Sc, Ph.D, CSIR UGC - NET JRF, IIT - GATE)
Founder & Director, Dalal Institute
Contact No: +91-9802825820
Homepage: www.mandeepdalal.com
E-Mail: dr.mandeep.dalal@gmail.com

Mandeep Dalal is an Indian research scholar who is primarily working in the field of Science and Philosophy. He received his Ph.D in Chemistry from Maharshi Dayanand University, Rohtak, in 2018. He is also the Founder and Director of "Dalal Institute", an India-based educational organization which is trying to revolutionize the mode of higher education in Chemistry across the globe. He has published more than 40 research papers in various international scientific journals, including mostly from Elsevier (USA), IOP (UK) and Springer (Netherlands) .

Other Books by the Author

A TEXTBOOK OF INORGANIC CHEMISTRY - VOLUME I, II, III, IV

A TEXTBOOK OF PHYSICAL CHEMISTRY - VOLUME I, II, III, IV

A TEXTBOOK OF ORGANIC CHEMISTRY - VOLUME I, II, III, IV

ISBN: 978-81-938720-0-0
9 788193 872000
MRP: Rs 800.00

DALAL INSTITUTE
Main Market, Sector 14, Rohtak, Haryana 124001, India
(+91-9802825820, info@dalalinstitute.com)
www.dalalinstitute.com