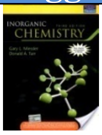
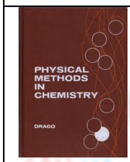
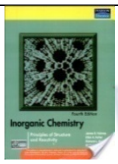
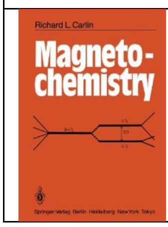
KNOW MORE

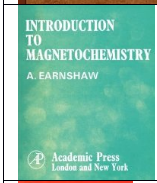
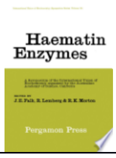
Principal Investigator		Co- Principal Investigator and Technical Coordinator
Prof A.K.Bakhshi Sir Shankar Lal Professor, Department of Chemistry University of Delhi		**Dr Vimal Rarh** Deputy Director, Centre for e-Learning and Assistant Professor, Department of Chemistry, SGTB Khalsa College, University of Delhi *Specialised in : e-Learning and Educational Technologies*
Paper Coordinator	**Content Writer**	**Reviewer**
Dr Rajeev Gupta, Associate Professor, Department of Chemistry, University of Delhi	**Dr. Rajeev Gupta** Associate Professor, Department of Chemistry, University of Delhi **Dr Jyoti Singh** Assistant Professor, Zakir Hussain Delhi College University of Delhi	**Prof D S Pandey** Professor Faculty of Science Department of Chemistry Banaras Hindu University Varanasi
Anchor Institute : SGTB Khalsa College, University of Delhi		

Web links

- https://books.google.co.in/books?id=spj0RfW903kC&pg=PA17&lpg=PA17&dq=Equilibrium+between+two+spin+states&source=bl&ots=bPa4sEhT-a&sig=ROQ_RY5w58Hh_dyX3C2T126IXGo&hl=en&sa=X&ved=0CDkQ6AEwBGoVChMI3sOHkI7fxgIVRXOOCh0JkQqT#v=onepage&q=Equilibrium%20between%20two%20spin%20states&f=false
- http://en.wikipedia.org/wiki/Magnetism
- http://wwwchem.uwimona.edu.jm/courses/magnetism.html
- https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/transition-metals-22/bonding-in-coordination-compounds-crystal-field-theory-160/magnetic-properties-616-6882/
- http://en.wikipedia.org/wiki/Transition_metal
- http://chemwiki.ucdavis.edu/Inorganic_Chemistry/Crystal_Field_Theory/Crystal_Field_Theory/Magnetic_Properties_of_Coordination_Complexes

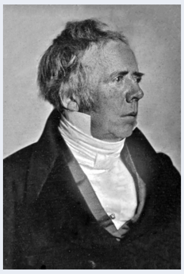
Suggested Readings

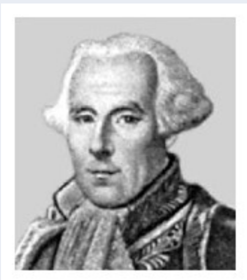
	Miessler, G. L.; Tarr, D. A. (2003). Inorganic Chemistry (3rd ed.). Pearson Prentice Hall. ISBN 0-13-035471-6
	Drago, R. S.Physical Methods In Chemistry. W.B. Saunders Company. ISBN 0721631843 (ISBN13: 9780721631844)
	Huheey, J. E.; Keiter, E.A. ; Keiter, R. L. ; Medhi O. K. Inorganic Chemistry: Principles of Structure and Reactivity.Pearson Education India, 2006 - Chemistry, Inorganic
	Carlin, R. L. Magnetochemistry. SPRINGER VERLAG GMBH. ISBN 10: 3642707351 / ISBN 13: 9783642707353

	SELWOOD, P. W. MAGNETOCHEMISIRY. Swinburne Press. ISBN 1443724890.
	Earnshaw, A. Introduction to Magnetochemistry Academic Press. ISBN 10: 1483255239 / ISBN 13: 9781483255231
	Lacheisserie É, D. T. De; Gignoux, D., Schlenker, M. Magnetism
	J. E. Falk, R. Lemberg, R. K. Morton . Haematin Enzymes: A Symposium of the International Union of Biochemistry. Pergamon Press

Time-Lines

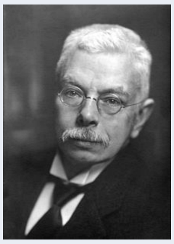
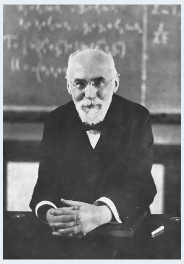
Timelines	Image	**Description**
1600	 **Source:** http://en.wikipedia.org/wiki/William_Gilbert_(astronomer)	Dr. William Gilbert published the first systematic experiments on magnetism in "De Magnete".

1777	 http://en.wikipedia.org/wiki/Charles-Augustin_de_Coulomb	Charles-Augustin de Coulomb showed that the magnetic repulsion or attraction between magnetic poles varies inversely with the square of the distance r.
1819	 http://en.wikipedia.org/wiki/Hans_Christian_%C3%98rsted	Hans Christian Ørsted accidentally made the connection between magnetism and electricity discovering that a current carrying wire deflected a compass needle.
1820	 http://en.wikipedia.org/wiki/Andr%C3%A9-Marie_Amp%C3%A8re	André-Marie Ampère discovered that the magnetic field circulating in a closed-path was related to the current flowing through the perimeter of the path.

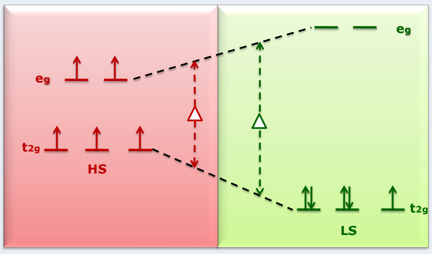
1820	 http://en.wikipedia.org/wiki/Carl_Friedrich_Gauss  http://en.wikipedia.org/wiki/Jean-Baptiste_Biot  http://www.appl-lachaise.net/appl/article.php3?id_article=682	Carl Friedrich Gauss; Jean-Baptiste Biot and Félix Savart, came up with the Biot–Savart law giving an equation for the magnetic field from a current-carrying wire.
1825	 http://en.wikipedia.org/wiki/William_Sturgeon	William Sturgeon invented the electromagnet.

1831	 http://en.wikipedia.org/wiki/File:M_Faraday_Th_Phillips_oil_1842.jpg	Michael Faraday, found that a time-varying magnetic flux through a loop of wire induced a voltage, and others finding further links between magnetism and electricity.
1831	 http://en.wikipedia.org/wiki/Joseph_Henry	Joseph Henry discovered electromagnetic induction independently of and at about the same time as Michael Faraday. In physics, and electronics, the henry (symbol H) is the SI derived unit of inductance. It is named after Joseph Henry.
1861	 http://en.wikipedia.org/wiki/James_Clerk_Maxwell	James Clerk Maxwell, a Scottish mathematical physicist, proposed a set of mathematical equations describing physical explanation of electricity and magnetism.

1880	 http://en.wikipedia.org/wiki/Emil_Warburg	E. Warburg produced the first hysteresis loop for iron.
1885	 http://en.wikipedia.org/wiki/Oliver_Heaviside	Oliver Heaviside coined the term Magnetic permeability.
1895	 http://en.wikipedia.org/wiki/Pierre_Curie	Pierre Curie proposed Curie law.

1896	 https://en.wikipedia.org/wiki/Pieter_Zeeman#/media/File:Pieter_Zeeman.jpg  https://en.wikipedia.org/wiki/Hendrik_Lorentz#/media/File:Hendrik_Antoon_Lorentz.jpg	**P. Zeeman** discovers the splitting of atomic line spectra by a magnetic field. **Lorentz** gives an electron theory of the ***Zeeman effect***
1897	 https://en.wikipedia.org/wiki/J._J._Thomson#/media/File:J.J_Thomson.jpg	**J. Thomson** argues that cathode rays must be charged particles smaller in size than atoms Emil Wiechert made the same suggestion independently in this same year.

1905	 http://en.wikipedia.org/wiki/Paul_Langevin	Paul Langevin explained the theory of diamagnetism and paramagnetism.
1906	 http://theor.jinr.ru/~kuzemsky/pwbio.html	Pierre-Ernest Weiss proposed ferromagnetic theory.
1920's	 http://en.wikipedia.org/wiki/John_Hasbrouck_Van_Vleck	John Hasbrouck Van Vleck developed the physics of magnetism with theories involving electron spins and exchange interactions; the beginnings of quantum mechanics. In 1932, He wrote a book on "Theory of Electric and Magnetic Susceptibilities"

1931		L. Cambi and L.Szego observed Spin Cross Over in Fe(III) dithiocarbamates
1932	 http://en.wikipedia.org/wiki/Louis_N%C3%A9el	Louis Eugène Félix Néel suggested a new form of magnetic behavior called antiferromagnetism. In 1947, Néel discovered ferrimagnetism in some materials.
1948	 https://en.wikipedia.org/wiki/Julian_Schwinger#/media/File:Schwinger.jpg	Julian Schwinger suggested the **anomalous magnetic moment** of a particle.
1960		R. Carl Stoufer, Daryle H. Busch and Wayne B. Hadley reported the first Co^{II} SCO complex

Did You Know?

Example of spin equilibrium in Nature

One of the most interesting cases of spin equilibrium occurs among the ferrihaemoprotein hydroxides. Ferrihaemoprotein hydroxides include ferrihaemoglobin hydroxide, ferrimyoglobin hydroxide, ferripeoxidase hydroxide and ferricytochrome c hydroxide. In **1937,** Pauling and his co-workers founded that the magnetic moment of ferrihaemoglobin hydroxide is 4.7 B.M**.** This differs considerably from that of the F^- (5.92 **B.M.)** and from those of the CN^- and SH^-, 2.5 and 2.26 B.M., derivatives respectively. Since that time there has been a continuing discussion of the electronic structures of such complexes. The first workers postulated a configuration with **3** unpaired electrons corresponding to an intermediate spin state between high-spin (S = 5/2**)** and low-spin **(S** =1) configurations. According to the studies, Ferrihaemoprotein hydroxides are the thermal mixtures of low spin and high spin forms. The magnetic moments of ferrihaemoprotein hydroxides are given in table

Ferrihaemoprotein hydroxides	Magnetic moment μ (B.M)
ferrihaemoglobin hydroxide	4.47
ferrimyoglobin hydroxide	5.11
ferripeoxidase hydroxide	2.66
ferricytochrome c hydroxide	2.14

The value of magnetic moment for these ferrihaemoprotein hydroxides suggest that ferrihaemoglobin hydroxide is the mixture of low spin and high spin forms, ferrimyoglobin hydroxide is close to high spin form, whereas ferripeoxidase hydroxide and ferricytochrome c hydroxide exists as low spin complexes. Assuming ferrihaemoprotein hydroxides as thermal mixtures and adopting μ_h= 5.92 and μ_h= 2.24 as the magnetic moments of high spin and low spin forms, calculations gives the following percentages for various ferrihaemoprotein hydroxides;

Ferrihaemoprotein hydroxides	% High Spin	% Low Spin
ferrihaemoglobin hydroxide	50	50
ferrimyoglobin hydroxide	70	30
ferripeoxidase hydroxide	7	93