Weiss theory of ferromagnetism

It is based on the following assumptions :

(i) The atomic dipoles of the ferromagnetic substances are grouped together in domains . In each domain the dipoles are all aligned in the same direction and have magnetic moment . In absence of external magnetic field the domains is spontaneously magnetised . The direction of magnetisation in different domains are different in an unmagnetised substance . Hence on average the resultant magnetisation is zero .

(ii) The cause of spontaneous magnetisation within each domain is the existence of the molecular field which tries to produce a parallel alignment of the dipoles . Again , this internal field H_m varies as the magnetisation M within a domain . Thus

$$H_m = \gamma M \qquad (1)$$

Where γ = Molecular field constant . It does not depend on temperature .

If H is the external magnetic field . Then the effective magnetic field acting on an atom or ion can be written as

$$H_e = H + \gamma M \qquad (2)$$

Let N be the number of atoms per unit volume J be the total angular momentum quantum number of each atom then the possible components of magnetic moment is

$$M_J \, g \, \mu_B$$

Where M_J = J, (J-1) , …. – (J-1) , -J

= Magnetic quantum number associated with J .

Thus the potential energy of atomic dipole with component $M_J \, g \, \mu_B$ along H ,

$$= - M_J \, g \, \mu_B \, H \qquad (4)$$

Where g = Lande’s splitting factor

$$= 1 + J(J+1) + S(S+1) – L(L+1) / 2J(J+1)$$

μ_B = Bohr magneton

L = Orbital angular momentum of each atom

S = Spin angular momentum of each atom

Now from the principle of statistical mechanics , the total magnetic moment per unit volume or the magnetisation along H is

$$M = N \sum_{-J}^{+J} M_J \, g \, \mu_B \, e^{M_J g \mu B}/KT \; / \; \sum_{-J}^{+J} e^{M_J g \mu B}/KT \qquad (5)$$

On solving above equation , we get

$$M = N g J \mu_B B_J (\chi) \qquad (6)$$

For magnetic material H replaced by $H + \gamma M$, hence we get

$$\chi = gJ \mu_B (H + \gamma M) / KT \qquad (7)$$