

Magnetism
(Langevin's theory of para magnetism)

Lecture - 6

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Langevin's theory of paramagnetism

Langevin gave a theoretical interpretation of paramagnetism on the basis of the kinetic theory of gas obtained a quantitative relation for the paramagnetic gas which justify the experimental results .

The molecules of the paramagnetic gas are supposed to be small permanent magnets due to circulating electrons .When the external magnetic field not present , the magnetic axis of the molecules are uniformly distributed in all directions .

Hence the sum of the projections of the elementary moments on any of the reference is zero .When the magnetic field is applied, the molecules will tend to orient themselves with their magnetic axes in the field direction .

We discuss an ensemble of non - interacting magnetic moments with the same origin in the applied field, H , at the temperature, T . The probability of occupying an energy state,

$E = -\mathbf{m} \cdot \mathbf{H}$, is given by Boltzmann statistics, that is,

$$\exp(-E/kT) = \exp(mH \cos\theta / KT)$$

Where θ is an angle between magnetic moment m and Applied field H , K is the Boltzmann constant and T is the absolute temperature .

One has to know the number of the magnetic moments lying between the angle θ and $\theta + d\theta$

The number of molecules whose axes fall within the solid angle between two hollow cones of semi angles θ and $\theta + d\theta$ is given by

$$dn = 2\pi \sin\theta d\theta \exp MH \cos\theta / KT$$

where $2\pi \sin\theta d\theta =$ solid angle

$K =$ Boltzmann constant

The average value of magnetic moment in field direction is