**CL50_Q1. Describe Quantum theory of Para magnetism.**

Based on quantum theory of Para magnetism, the magnetic dipoles of a molecule / atom /ion in a material can be written as $\boldsymbol{\mu = g\mu_B m_j}$ , where $g_e$ is the Lande g factor and $\mu_B$ is the Bohr magneton. In an external magnetic field B the dipoles are allowed only certain fixed orientations of the total angular momentum J and described by $M_j$. For a given J (the total angular momentum) the allowed orientations are 2j+1 (j, j-1,j-2…..0 …..-j) and the energy of interaction with an external magnetic field B is given by $\boldsymbol{E_j = \mu . B = g\mu_B m_j . B = g\mu_o \mu_B H m_j}$

For a material with N dipoles per unit volume, the net magnetization is the statistical average of the allowed $\mu_j$ orientations and is given by

$$\boldsymbol{M} = \mathrm{N}\left[\frac{\sum_{-j}^{+j} m_j g \mu_B * \exp\left({}^{m_j g \mu_o \mu_B H}/_{kT}\right)}{\sum \exp\left({}^{m_j g \mu_o \mu_B H}/_{kT}\right)}\right]$$

Which clearly indicate that, the magnetization will depend on the value of the exponent $\left(\frac{m_j g \mu_o \mu_B H}{kT}\right)$.

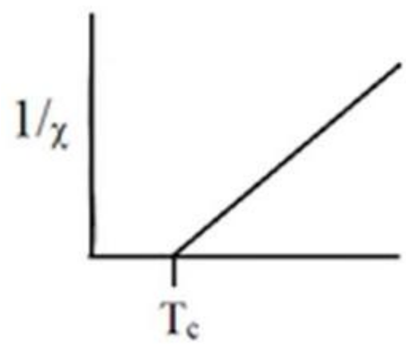
**CL50_Q2. Discuss Weiss theory of spontaneous magnetization and express susceptibility in terms of the modified Curie-Weiss law**

**Ans:**

The variation susceptibility as a function of temperature is expected to be a straight line. But some materials show a variation in this behaviour with the straight line showing a positive intercept $T_c$ on the temperature axis.

Weiss showed that this could be due to a molecular field which is the field at any point due to the neighbouring dipoles. If M is the magnetization in the material, then the magnetic field at any point is proportional to M and hence the field at any point in the material could have an additional contribution =λM.

This field has the tendency to align the dipoles in the direction of the field and hence would be a case of spontaneous magnetisation. Therefore the Curies law is modified as $\frac{M}{H+\lambda M} = \frac{C}{T}$ which gives us $\chi = \frac{C}{T-T_c}$ where $T_c = \lambda C$ is the Curie temperature above which the materials shows the paramagnetic behaviour. Below Tc the material behaves as a ferromagnetic material.




**CL50_Q3. Explain how Curie law is modified by internal molecular field and mention the significance of Curie temperature?**

**Ans:**

According to Weiss, by incorporating the molecular field due to the neighbouring dipoles, the field at any point in the material could have an additional contribution of λM. Therefore the Curie's law is modified as $\frac{M}{H+\lambda M} = \frac{C}{T}$

Or $\chi = \frac{C}{T-T_c}$ where $T_c = \lambda C$ is the Curie temperature.

Above Curie temperature materials show the paramagnetic behaviour and below $T_c$ the material behaves as a ferromagnetic.