CL51_Q1. Elaborate on spin ordered magnetic materials and their classification.

Ans:

Based on the spin ordering magnetic materials are classified as

Ferromagnetic materials: In case of ferromagnetic materials, there is a long range ordering of the magnetic dipoles due to the spin that leads to strong magnetization. Ferromagnetic materials have very high magnetic susceptibilities. Ferromagnetic materials exhibit spontaneous magnetization and exhibit sharp hysteresis characteristics

Anti-ferromagnetic materials: The class of anti-ferromagnetic materials such as MnO, NiO, CoO etc in which the electron spins associated with the atoms at different crystallographic sites are ordered such that the net magnetization of the material is zero below a certain temperature called as the Neel temperature T_N. Above the Neel temperature the material behaves as paramagnetic with the magnetic susceptibility inversely proportional to temperature.

Ferri magnetic materials: Ferri-magnetic materials are a class of ordered structures in which the magnetic moments at particular crystal sites are anti-parallel and unequal. These materials are treated as two sub lattices of a crystal with different magnetic moments and anti parallel alignments. Generally, these materials contain cations of two or more types with different magnetic moments and hence show a net magnetization not equal to zero. Examples of such materials are $NiFe_2O_4$, $CoFe_3O_4$, and $BaFe_{12}O_{19}$ etc.

Paramagnetic materials: Dipoles do not interact with each other in case of paramagnetic materials

CL51_Q2. Discuss the temperature dependence of susceptibility for each type of magnetic material.

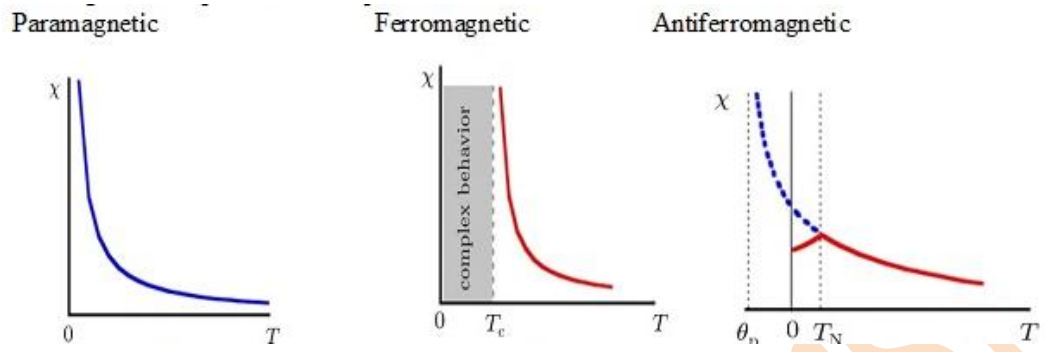
Answer

The temperature dependence of the susceptibility for para, ferro and antiferro magnetic materials is summarized as below.

For paramagnetic materials the susceptibility χ_m varies monotonically as $1/T$ following the Curie's law.

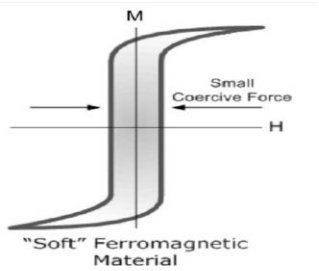
Ferromagnetic materials follow the Curie Weiss law and exhibit a paramagnetic behaviour above the Curie temperature.

Anti-ferromagnetic materials show an increase in susceptibility till the Neel temperature above which the material behaves as a paramagnetic material.



CL51_Q3. Distinguish between soft and hard magnets with the help of hysteresis graphs.

Soft magnetic



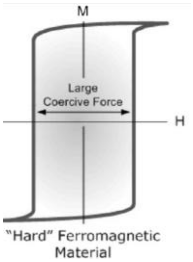
(1) It can be magnetized and de-magnetized.

(2) It is characterized smaller coercivity and large saturation magnetization.

(3) Hysteresis loop is narrow and has low losses.

Soft magnetic materials find application in high frequency switching of the magnetization and are used in transformers, motors and generators.

Hard magnetic



(1) It is hard to magnetized and de-magnetized.

(2) They exhibit a very high retentivity and require a large coercive field to de-magnetize the material

(3) Hysteresis loop is large and has high losses.

The high retentivity of the material makes it ideal for magnetic storage of information as in hard disk drives.