

Classification of magnetic materials

On the basis of the behaviour of materials in a magnetising field, the materials are generally classified into three categories namely,

(i) Diamagnetic, (ii) Paramagnetic and (iii) Ferromagnetic

(i) Properties of diamagnetic substances

Diamagnetic substances are those in which the net magnetic moment of atoms is zero.

1. The susceptibility has a low negative value. (For example, for bismuth $\chi_m = -0.00017$).
2. Susceptibility is independent of temperature.
3. The relative permeability is slightly less than one.
4. When placed in a non uniform magnetic field they have a tendency to move away from the field. (i.e) from the stronger part to the weaker part of the field. They get magnetised in a direction opposite to the field as shown in the Fig..
5. When suspended freely in a uniform magnetic field, they set themselves perpendicular to the direction of the magnetic field (Fig.).

Examples : Bi, Sb, Cu, Au, Hg, H₂O, H₂ etc

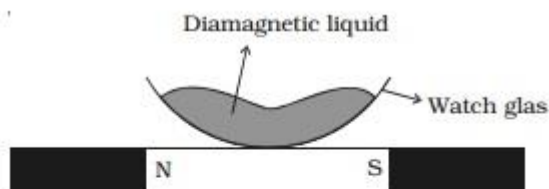


Fig. Diamagnetic liquid

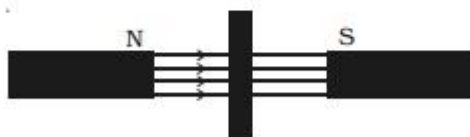


Fig. Diamagnetic material perpendicular to the field

(ii) Properties of paramagnetic substances

Paramagnetic substances are those in which each atom or molecule has a net non-zero magnetic moment of its own.

1. Susceptibility has a low positive value. (For example : χ_m for aluminium is +0.00002).
2. Susceptibility is inversely proportional to absolute temperature (i.e) $\chi_m \propto 1/T$. *As the temperature increases susceptibility decreases.*
3. The relative permeability is greater than one.
4. When placed in a non uniform magnetic field, they have a tendency to move from weaker part to the stronger part of the field. They get magnetised in the direction of the field as shown in Fig.
5. When suspended freely in a uniform magnetic field, they set themselves parallel to the direction of magnetic field (Fig.).

Examples : Al, Pt, Cr, O₂, Mn, CuSO₄ etc.

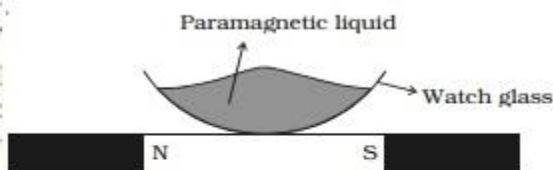


Fig. Paramagnetic liquid

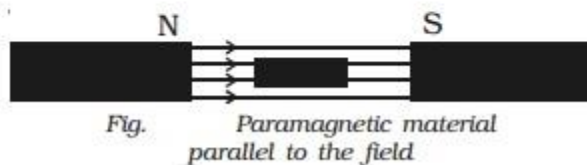


Fig. Paramagnetic material parallel to the field

(iii) Properties of ferromagnetic substances

Ferromagnetic substances are those in which each atom or molecule has a strong spontaneous net magnetic moment. These substances exhibit strong paramagnetic properties.

1. The susceptibility and relative permeability are very large. (For example : μ_r for iron = 200,000)
2. Susceptibility is inversely proportional to the absolute temperature.

(i.e) $\chi_m \propto 1/T$. As the temperature increases the value of susceptibility

decreases. *At a particular temperature, ferro magnetics become para magnetics. This transition temperature is called curie temperature.* For example curie temperature of iron is about 1000 K.

3. When suspended freely in uniform magnetic field, they set themselves parallel to the direction of magnetic field.

4. When placed in a non uniform magnetic field, they have a tendency to move from the weaker part to the stronger part of the field. They get strongly magnetised in the direction of the field.

Examples : Fe, Ni, Co and a number of their alloys.

Properties	Ferromagnetic Materials	Paramagnetic Materials	Diamagnetic
State	They are solid.	They can be solid, liquid or gas.	They can be solid, liquid or gas.
Effect of Magnet	Strongly attracted by a magnet.	Weakly attracted by a magnet.	Weakly repelled by a magnet.

Properties	Ferromagnetic Materials	Paramagnetic Materials	Diamagnetic
Behavior under non-uniform field	tend to move from low to high field region.	tend to move from low to high field region.	tend to move from high to low region.
Behavior under external field	They preserve the magnetic properties after the external field is removed.	They do not preserve the magnetic properties once the external field is removed.	They do not preserve the magnetic properties once the external field is removed.
Effect of Temperature	Above curie point, it becomes a paramagnetic.	With the rise of temperature, it becomes a diamagnetic.	No effect.
Permeability	Very high	Little greater than unity	Little less than unity
Susceptibility	Very high and positive	Little greater than unity and positive	Little less than unity and negative
Examples	Iron, Nickel, Cobalt	Lithium, Tantalum, Magnesium	Copper, Silver, Gold