B.Sc. (Honours) Part-I

Paper-IB

Topic: **Elementary Magnetochemistry: Paramagnetism**

UG

Subject-Chemistry

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Elementary Magnetochemistry: Paramagnetism

MAGNETIC MATERIALS

Magnetic force is one of the oldest physical phenomena that human knows. The story of magnetism and magnetic materials begins with minerals called 'Magnetite (Fe_3O_4)', Hematite (Fe_2O_3) the first magnetic minerals known to man. Magnetism, The phenomenon by which materials assert an attractive or repulsive force or influence on other materials.

Paramagnetic Materials

A paramagnetic material contains permanent dipoles which are because of incomplete cancellation of electron spin and orbital magnetic moments which results in a resultant magnetic moment even in the absence of applied field. In the absence of external magnetic field the dipoles are randomly oriented resulting in zero net magnetic moment. When external magnetic field is applied, some of the permanent dipoles try to align in the direction of the magnetic field (Fig. 1). Since few dipoles try to align in the direction of the magnetic field the net magnetic moment produced in the material is small so the material is feebly magnetised. When placed inside the magnetic field the material allows magnetic lines of force to pass through it as shown in Fig. 2. There is no interaction between the adjacent dipoles they are acted upon individually. The relative permeability is greater than unity. Magnetic susceptibility is positive but relatively small value. The susceptibilities of paramagnetic values range from 10^{-5} to 10^{2}. These materials are used in lasers and masers. Where one can create the required energy levels of transition.

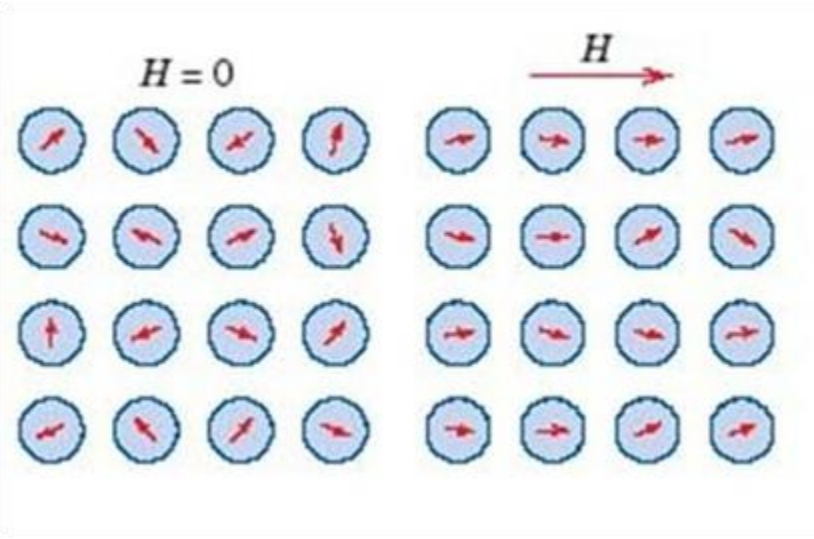

Fig. 1 Atomic dipole configuration with and without external magnetic field for a paramagnetic material

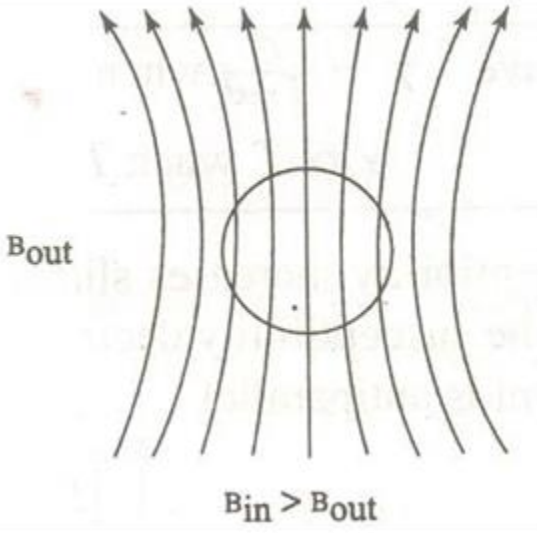

Fig. 2: Behaviour of paramagnetic material in external magnetic field.

Paramagnetic property of oxygen is used in the NMR imaging instrument which is used to diagnose the brain tumour or blood clot in t he brain.

Table 2: Room temperature magnetic susceptibility for paramagnetic material

Paramagnetics	
Material	***Susceptibility χ_m (volume) (SI units)***
Aluminum	2.07×10^{-5}
Chromium	3.13×10^{-4}
Chromium chloride	1.51×10^{-3}
Manganese sulfate	3.70×10^{-3}
Molybdenum	1.19×10^{-4}
Sodium	8.48×10^{-6}
Titanium	1.81×10^{-4}
Zirconium	1.09×10^{-4}

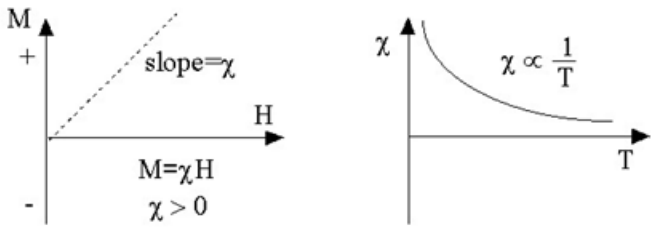

Fig. 3: Curves showing M Vs H and χ Vs T for paramagnetic materials

As H increases M also increases in the same fashion which results in a straight line passing through origin. The slope of the curve gives susceptibility which is positive and relatively small value. The curve shows that the susceptibility of paramagnetic material is dependent of temperature. With increase in temperature the susceptibility of the paramagnetic material decreases.

Properties of paramagnetic materials

1. They attract magnetic lines of force when placed in magnetic field.
2. In the absence of external magnetic field the dipoles are randomly oriented.
3. An atom of this material possesses a non-zero magnetic dipole moment.
4. Possess permanent dipole moment.
5. Relative permeability is slightly greater than unity.
6. Magnetic susceptibility is positive and small.
7. Magnetic susceptibility is independent of applied magnetic field strength but depend on temperature.
8. With increase in temperature the susceptibility of the material decreases.
9. Examples: Aluminium, Platinum, Manganese, Copper Chloride, Oxygen, solutions of salts of iron.