Magnetochemistry

Behaviour of Inorganic chemicals in an applied Magnetic field has provided important clues to our understanding of the nature of bonding, valence and stereochemistry of such substances. For this the discussion in this field becomes necessary.

First of all, we are discussing about some common terms —

a) **Pole strength**:- A unit pole is defined as one which when placed in vacuum 1 cm away from another unit pole repels or attracts it by 1 dyne force.

b) **Intensity of a Magnetic field**:- A magnetic field is said to have unit intensity at a point if it exerts a force of one dyne on a unit pole placed at that point. It is also expressed in one unit of lines of force passing through 1 cm^2.

c) **Intensity of magnetisation (I)**:- This is defined as the pole-strength induced per unit area. If 'm' be the pole strength induced over an area 'A' and 'l' be the length of magnetic dipole, then —

$$I = \frac{m}{A} = \frac{m \times l}{A \times l} = \frac{\mu}{V}$$

$$\therefore I = \frac{\text{magnetic moment } (\mu)}{\text{volume } (V)}$$

d) **Gauss's Law and Magnetic Induction**:- Let, a unit pole is enclosed in a sphere of radius 1 cm (surface area 4π sq cm). By definition, it will act upon another unit pole anywhere on the surface of this sphere with a force of 1 dyne i.e. it will generate a unit magnetic field all over the surface since a unit magnetic field gives unit line of force $1\ cm^2$. It follows 4π lines of force will come out from a unit pole.

Gauss's law states that the magnetic induction over a closed surface is 4π times the pole enclosed. Thus the total magnetic induction (B) is given by—

$$B = H + 4\pi I$$

$$\therefore \frac{B}{H} = 1 + \frac{4\pi I}{H}$$

$$\text{or } P = 1 + 4\pi K \quad \text{—(1)}$$

Where H = strength of the applied field

B = the total no. of lines of force across a unit surface of the material which has subjected to H lines of force due to imposed field.

(where $B/H = P$ = magnetic permeability

$I/H = K$ = magnetic susceptibility per unit volume / volume susceptibility)

Significance:— The significance of this equation (1) is meaningful—

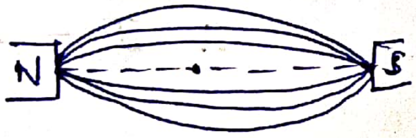
i) when no material is placed within the poles of applied magnetic field of strength H, then —

$$B = H$$

$$\therefore 1 + 4\pi K = 1$$

$$\text{or } 4\pi K = 0$$

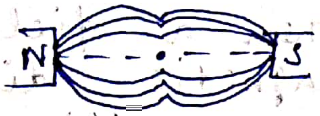
$$\text{or } K = 0$$



vacuum, $B/H = 1$

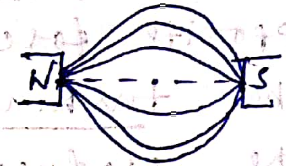
This means that vacuum has an magnetic permeability 1 $(P = B/H)$ and magnetic susceptibility 'zero'.

ii) If $B/H > 1$, that means the substance has a magnetic permeability greater than 1 i.e. magnetic lines of force prefer to pass through the substance than vacuumm. The substance is said to be paramagnetic and it has a positive magnetic susceptibility [$K = (+ve)$]



$B/H > 1$, $K = (+ve)$

iii) In most cases $B/H < 1$, this means that the magnetic lines of force tends to avoid the substance, then the substance is said to be diamagnetic and it has a (−ve) value of magnetic susceptibility ($K = -ve$)



$B/H < 1$, $K = (-ve)$

Thus it can be said that a paramagnetic substance is attracted by magnetic field and a diamagnetic substance is repelled by magnetic field.

e) Magnetic permeability (P) :– Magnetic Permeability of a substance may be defined as the ratio of density of lines of force within the body to the density of lines of force in vacuumm.

f) gram-susceptibility (X_g) :– It is defined as the magnetic susceptibility per gram of the substance and it is denoted by X_g. If d be the density of the substance, then –

$$X_g = \frac{K}{d} = \frac{\text{volume susceptibility}}{\text{density}}$$

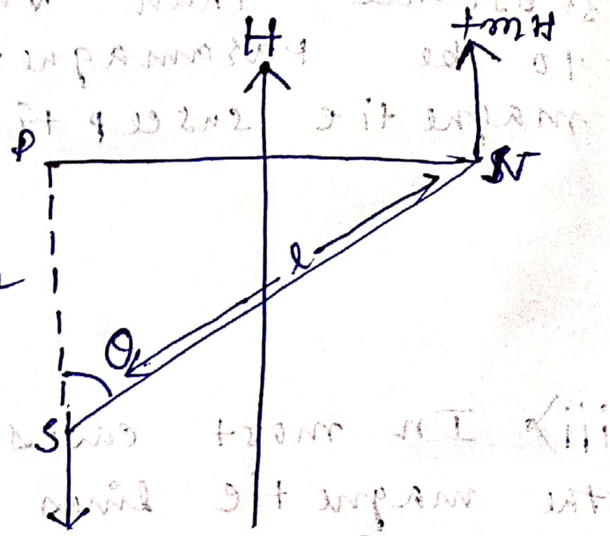
Here X_g is also known as specific / weight susceptibility

$\chi_M = \chi_g \times M$ where χ_M = Molar susceptibility

M = Molecular weight of the substance

g) Magnetic Moment (μ) :-

When a field acts on a magnetic dipole NS of length 'l' and pole strength 'm', its N and S pole will experience a force of $-mH$ and $+mH$ respectively.



These two equal but opposite forces constitute a couple, the turning moment which is the product of force and distance i.e.

$\frac{PS}{NS} = \sin\theta$

or $\frac{PS}{l} = \sin\theta$

or $PS = l\sin\theta$

$$\text{turning moment} = mH \cdot PS$$
$$= mH \cdot l\sin\theta$$
$$= m \cdot l \cdot H\sin\theta$$
$$= \mu\sin\theta$$

The quantity $\mu = ml$ defines the magnetic moment and it serves as a measure of the turning effect. The magnetic susceptibility of a substance is experimentally determined and it is converted into magnetic moment. The determined moment is then compared with theoritically predicted value and important conclusions regarding the valence state, structure, bonding etc. of the central metal ion are made.

Scanned with CamScanner