Magnetic properties

- A substance through which the magnetic lines of force of an external magnetic field pass is paramagnetic.
- A substance becomes paramagnetic when it possesses unpaired electrons. Ex. Sc^{++}, Cr^{++}
- Para magnetism increases with increase in number of unpaired electrons.
- A substance through which magnetic lines of force do not pass and repelled is called diamagnetic.
- A substance which contains only paired electrons and no unpaired electrons is diamagnetic.

  Ex . KCl, Ti^{4+}, V^{5+}
- Ferromagnetism is a special case of paramagnetism
- A substance which contains unpaired electrons and which are aligned in the same direction is ferromagnetic. Ex. Fe, Co, Ni.
- Ferromagnetism disappears in the solution of substance.
- In paramagnetic substance, the field strength (B) in the substance is greater than the applied field (H). i. e $B > H$.
- In ferromagnetic substance, the field strength (B) in the substance is much greater than (H) i.e. $B >> H$ the applied field.
- In diamagnetic substance, the field strength (B) is less than the applied field. i.e $B < H$.
- Paramagnetic substance moves from a weaker part of the field to stronger part of the field.
- Diamagnetic substance moves from a stronger part of the field to weaker part of the field.
- In 3d –series for some metal ions like Co^{2+}, Fe^{2+} the experimental value of ⍰ is slightly more than calculated value of ⍰ due to contribution of orbital motion.
- Both spin and orbital motions of unpaired electrons will contribute to the net magnetic moment.
- Magnetic moment, $m_{S+L} = \sqrt{4S(S+1)+L(L+1)}$ BM

  S $\rightarrow$ Sum of the electron spin quantum numbers of all the unpaired electrons.

  L $\rightarrow$ Sum of the Azimuthal quantum number of all the unpaired electrons.
- B.M = Bohr magneton.

  $1BM = \frac{eh}{4\pi mc} = 9.273 \times 10^{-24}$ Joules $Tesla^{-1}$ in S.I units

  e = Charge of the electron

  h = Planck's constant

  m = Mass of an electron

  T = Tesla
- Angular momentum due to orbital motion of unpaired electrons is small and ignored in 3d series.

- There fore the magnetic moment is due to spin of unpaired electron only.
- The following spin only formula gives spin only magnetic moment.

  $m_s = \sqrt{4S(S+1)}\,BM = \sqrt{n(n+2)}\,BM$

  n = number of unpaired electrons

  S = sum of spin quantum number values

- For I 3d series of metal ions, the spin only magnetic moments are given below

Metal Ion	3d configuration	No.of Unpaired electron	Magnetic moment
Sc^{+++} Ti^{+++} Ti^{++} V^{++} Cr^{++} or Mn^{++} Mn^{++}or Fe^{+++} Fe^{++}	 $3d^0$ $3d^1$ $3d^2$ $3d^3$ $3d^4$ $3d^5$ $3d^6$	 0 1 2 3 4 5 6	0 1.7 – 1.8 2.8 – 3.1 3.7 – 3.9 4.8 – 4.9 5.7 – 6 5 – 5.6

- In II and III series transition elements, L must be included in the formula for m_{S+L}. Thus it is significant.