B.Sc. III PAPER-VI

Magnetic properties of lanthanides

For study of magnetic properties of lanthanides, we must know the electronic configuration of lanthanides series of elements. La^{+3}_{57} and Ce^{4+}_{58} ions have no 4-f electrons and Lu^{+3} or Yb^{+2} ions have 14 electrons in 4f ~~electron~~ orbitals.

La_{57} [54] $4f^1 5d^0 6s^2$, La^{+3} $4f^0$ ☐☐☐☐☐☐☐

or Ce_{58} [54] $4f^2 5d^0 6s^2$ Ce^{+4} $4f^0$ ☐☐☐☐☐☐☐

or Yb_{70} [54] $4f^{14} 5d^0 6s^2$ Yb^{+2} $4f^{14}$ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂

or Lu_{71} ~~[54] 4f~~

[54] $4f^{14} 5d^1 6s^2$ Lu^{+3} $4f^{14}$ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂

All these ions are diamagnetic in nature because they have either paired electrons or no electrons in 4f orbital. Except above four ions of lanthanides, all other f-state contains unpaired electrons and are paramagnetic with spin and orbital momentum. Here the energy difference between two successive levels of a multiplet i.e multiplet width is larger than thermal energy kT i.e strong L-S coupling. For these ions, the effective magnetic moment is given by -

$$\mu_{eff} = g\sqrt{J(J+1)} \quad B.M.$$

Where g (Lande splitting factor) is given by

$$g = 1 + \frac{S(S+1) - L(L+1) + J(J+1)}{2J(J+1)}.$$

But: La^{+3} or $Ce^{4+}(4f^0)$, $Gd^{3+}(4f^7)$ and Lu^{3+} or $Yb^{2+}(4f^{14})$ ions have s term, $L=0$ no orbital effect.

La_{57} [54] $4f^1 5d^0 6s^2$

Ce_{58} [54] $4f^2 5d^0 6s^2$

$\therefore La^{+3}$ or Ce^{4+} $4f^0$ ↑ | | | | | | |

$\therefore L = \Sigma ml = 0$

$\therefore$ Term = S

Gd_{64} [54] $4f^7 5d^1 6s^2$

Gd^{3+} $4f^7$ ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑

$\therefore L = \Sigma ml = -3-2-1+0+1+2+3 = 0$

$\therefore$ term = S.

For Lu_{71} and Yb_{70}, $L = \Sigma ml = -6-4-2+0+2+4+6 = 0$

term = S

$\therefore Lu^{+3}$ or Yb^{+2}, $4f^{14}$ ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓

For these ions when $L=0$, $J=S$, hence $g=2$

$$\mu_s = \sqrt{4S(S+1)} = \sqrt{n(n+2)} \quad B.M.$$