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Inorganic Chemistry

Department of Chemistry

L.S COLLEGE MUZAFFARPUR

B. R. A. BIHAR UNIVERSITY

Dr. Priyanka

TOPIC:-UNIT II, MAGNETIC PROPERTIES,SPIN ONLY FORMULA

SPIN ONLY FORMULA

We begin the discussion of magnetochemistry with the so called spin-only formula, an approximation that has limited, but useful, applications. Paramagnetism arises from unpaired electrons. Each electron has a magnetic moment with one component associated with the spin angular momentum of the electron and (except when the quantum number l = 0) a second component associated with the orbital angular momentum. For many complexes of first row d-block metal ions we can ignore the second component and the magnetic moment, μ can be regarded as being determined by the number of unpaired electrons, n (equation 1 & 2) . The two equations are related because the total spin quantum number S = $\frac{n}{2}$

$$\mu \text{ (spin only)} = \sqrt{S(s+1)} \quad \text{.....(1)}$$

$$\mu \text{ (spin only)} = \sqrt{n\ (n+2)} \quad \text{..... (2)}$$

The effective magnetic moment, μ_{eff}, can be obtained from the experimentally measured molar magnetic susceptibility, χ_m and is expressed in Bohr magnetons (BM) where 1 BM = 9.27 x 10^{-24} Joule T^{-1}. Equation (3) gives the relationship between μ_{eff} and χ_m; using SI units for the constants, this expression reduces to equation (4) in which χ_m is in $cm^3\,mol^{-1}$.

$$\mu_{eff} = \sqrt{\frac{3k\chi_m T}{L\,\mu_0\,\mu B^2}} \quad \text{..... (3)}$$

where k = Boltzmann constant; L = Avogadro number; μ_0 = vacuum permeability; T = temperature in Kelvin and χ_m is the molar suscptibility.

$$\mu_{eff} = 0.7977\sqrt{\chi_m T} \quad \text{.....(4)}$$

Spin-only values of μ_{eff} compared with approximate ranges of observed magnetic moments for high-spin complexes of first row d-block ions can be seen by Table 3.1.

Table 3.1. Comparison between the spin only and observed magnetic moments in high spin complexes of first row transition elements

Metal ion	d^n configuration	S	μ_{eff} (spin only) BM	Observed values of μ_{eff} BM
Sc^{+3}, Ti^{+4}	d^0	0	0	0
Ti^{+3}	d^1	½	1.73	1.7- 1.8
V^{+3}	d^2	1	2.83	2.8–3.1
V^{+2}, Cr^{+3}	d^3	3/2	2.87	3.7–3.9
Cr^{+2}, Mn^{+3}	d^4	2	4.90	4.8–4.9
Mn^{+2}, Fe^{+3}	d^5	5/2	5.92	5.7–6.0
Fe^{+2}, Co^{+3}	d^6	2	4.90	5.0–5.6
Co^{+2}	d^7	3/2	3.87	4.3–5.2
Ni^{+2}	d^8	1	2.83	2.9–3.9
Cu^{+2}	d^9	½	1.73	1.9–2.1
Zn^{+2}	d^{10}	0	0	0