Paramagnetic or diamagnetic?



$CuSO_4$
pulled IN ↓

$ZnSO_4$
pushed out (weak)

Paramagnetic: attracted into a magnetic field (e.g. Cu^{2+} salts).

Diamagnetic: weakly repelled (e.g. Zn^{2+} salts).

A **Gouy balance** shows it: the sample seems heavier when the magnet is on.

Every electron is a tiny magnet



alone: magnet stays

pair ↑↓: cancels

Each electron has a magnetic moment from its **spin**.

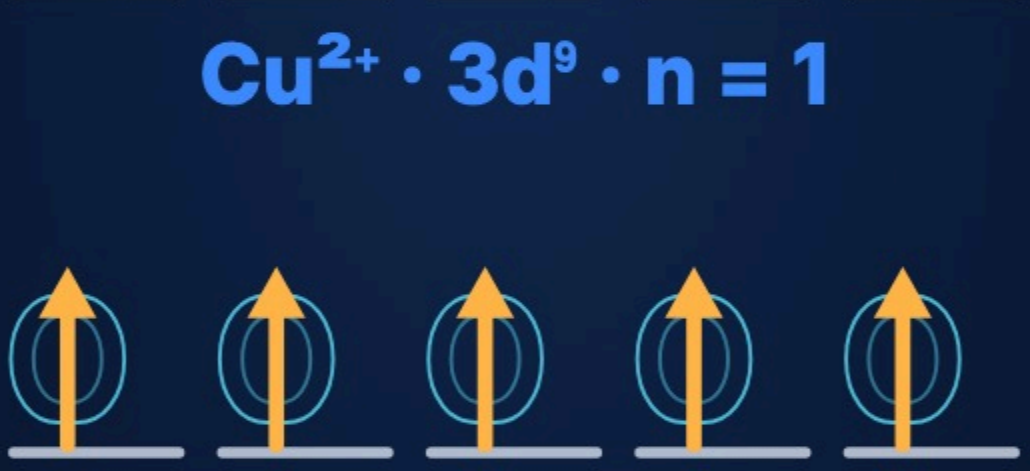
In a pair the spins are opposite: they **cancel**.

Only **unpaired electrons** cause paramagnetism.

Count the unpaired electrons



$Cu^{2+} \cdot 3d^9 \cdot n = 1$



$Mn^{2+} \cdot 3d^5 \cdot n = 5$

Fill the five 3d orbitals singly first (Hund's rule), then pair.

Write the ion's configuration: 4s electrons leave first ($Fe^{2+} = 3d^6$).

The counting rule

$$d^1 \ldots d^5 \rightarrow n = d$$

$$d^6 \ldots d^{10} \rightarrow n = 10 - d$$

$Fe^{2+}\ 3d^6 \rightarrow 4$

$Ni^{2+}\ 3d^8 \rightarrow 2$

$V^{2+}\ 3d^3 \rightarrow 3$

$Zn^{2+}\ 3d^{10} \rightarrow 0$

Up to d^5 every electron sits alone.

From d^6 electrons start pairing, so n falls again.

d^5 has the most unpaired electrons: 5.

Spin-only formula

$$\mu = \sqrt{(n(n+2))}\ \text{BM}$$

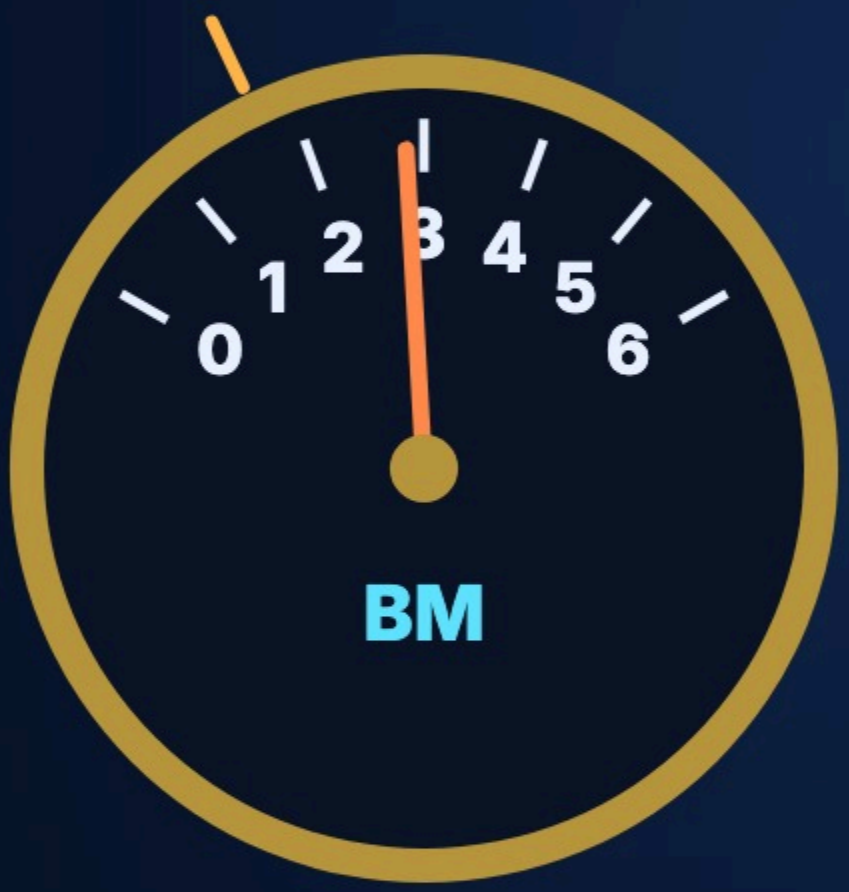
n = 0	n = 1	n = 2	n = 3	n = 4	n = 5
0	1.73	2.84	3.87	4.90	5.92

n = number of unpaired electrons
BM = Bohr magneton

For 3d ions the orbital part is **quenched**, so only spin counts.

One unpaired electron: $\sqrt{3} = 1.73$ BM.

It does not double



n = 2

2 × 1.73 = 3.46 ✗

√8 = 2.84 ✓

μ grows with n, but **not in proportion.**

Always use √(n(n+2)); never multiply 1.73 by n.

Measured vs calculated (NCERT Table 4.7)

ion	config.	n	calc.	observed
Ti^{3+}	$3d^1$	1	1.73	1.75
V^{2+}	$3d^3$	3	3.87	3.86
Mn^{2+}	$3d^5$	5	5.92	5.96
Cu^{2+}	$3d^9$	1	1.73	1.8–2.2
Zn^{2+}	$3d^{10}$	0	0	0

The measured μ tells you **n**: a magnet can count unpaired electrons.

Co^{2+} and Fe^{2+} read a little higher (orbital part not fully quenched).

Solved: NCERT Example 4.8

Z = 25, divalent ion in water



$$Mn^{2+} \cdot 3d^5 \cdot n = 5$$

$$\mu = \sqrt{(5 \times 7)} = \sqrt{35} = 5.92 \text{ BM}$$

Now try **Z = 27**, $M^{2+}(aq)$: find n, then μ.