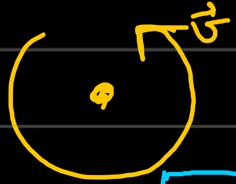
Lecture 31

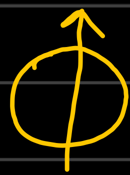
Magnetic Properties

Lorentz force: $F = -e\vec{E} + e(\vec{v} \times \vec{B})$

orbital angular momentum



spin angular momentum.



$$\boxed{\mu_{net} = \vec{\mu}_{orbit} + \vec{\mu}_{spin}}$$

$$\boxed{\mu_m^{orbite} = \frac{-e}{2m_e} L^{orbit}}$$

$L \rightarrow$ angular momentum.

$\mu_m \rightarrow$ magnetic moment

$$\boxed{\mu_m^{spin} = \frac{-e}{m_e} S}$$

$S \rightarrow$ spin quantum number.

Intrinsic magnetic moment of atoms:

↳ unpaired electrons in valence shell:

$Fe = [Ar]\,3d^6 4s^2$

↑↓	↑	↑	↑	↑

$3d^6$

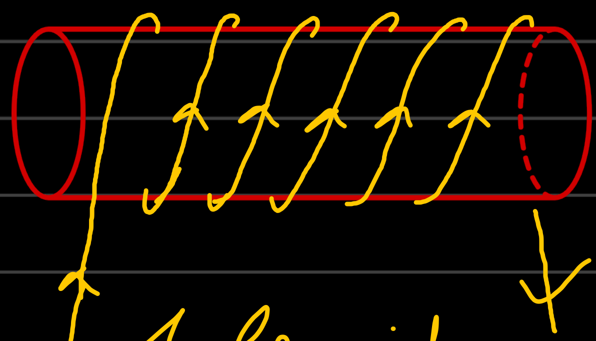
↑↓

$4s^2$

Si, NaCl crystals will not show magnetism.
↳ no intrinsic magnetic moments.
↳ exhibit diamagnetism.

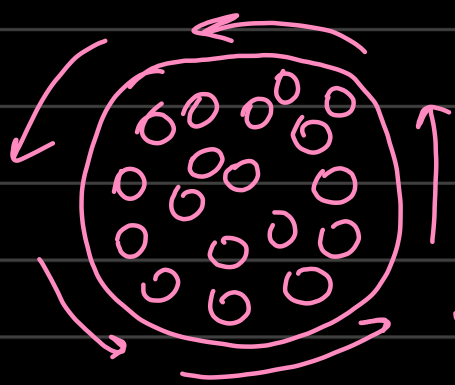
$$M = \frac{1}{\Delta V} \sum \mu_m$$

M → magnetization.



Solenoid

$B = \mu_0 N I$
in center of solenoid.



surface currents

If there is a net Magnetization, there is a net surface current.

Total Magnetization = Total orbital magnetic moment

$$M \times A \times L = I_m \times L \times A$$

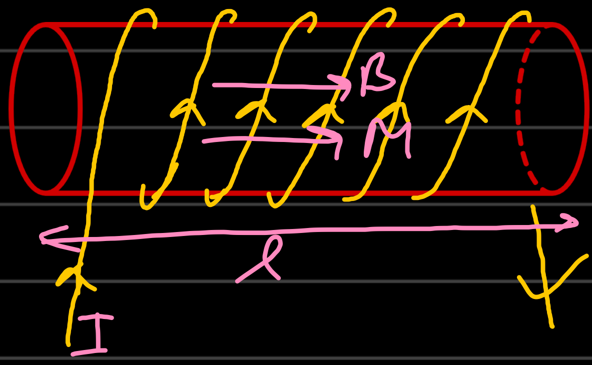
$$\boxed{M = I_m}$$

M → magnetization

I_m → surface currents per unit length.

$$B_{net} = \mu_0 n I + \mu_0 I_m$$

$$\boxed{B_{net} = B_0 + \mu_0 M}$$



H = magnetizing field intensity:

↳ magnetization only due to externally applied electric current.

$$H = \frac{B_0}{\mu_0} = nI$$

$$H = \frac{B}{\mu_0} - M$$

$$B = \mu_0 H + \chi_m H = \mu_0 \mu_r H$$

μ_r → magnetic permeability

$$\boxed{B = \mu_0 (1 + \chi_m) H}$$

χ_m → magnetic susceptibility

Types of magnetic interactions:

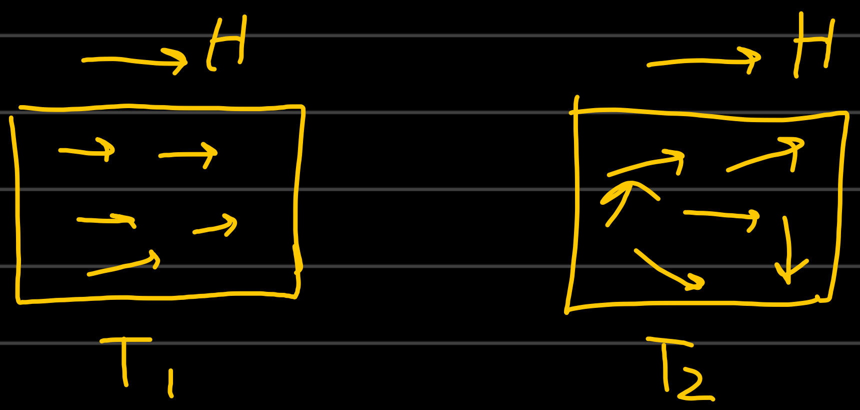
1) Paramagnetism: internal magnet moments, align with external field.

2) Diamagnetism: magnet moment induced opp to external field.

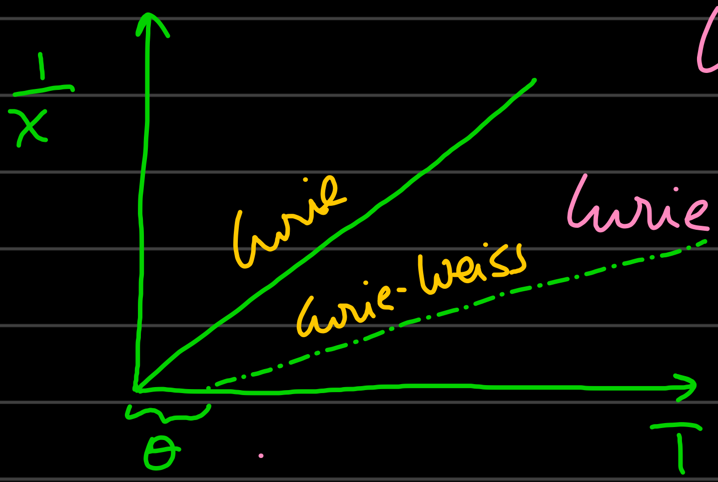
Paramagnetic Materials:

↳ materials with small & positive χ_m

↳ Eg: Oxygen.



$\{T_2 > T_1\}$



Curie's Law : $\chi = \frac{C}{T}$

Curie-Weiss : $\chi = \frac{C}{T-\theta}$

Ferromagnetism:

↳ susceptibility going to infinity!

$$M \neq 0 \ , \ H \to 0 \Rightarrow \chi \to \infty$$

Hund's Rule & Exchange Interactions:

$m_\ell = \quad -2 \quad -1 \quad 0 \quad 1 \quad 2$

$3d^6$

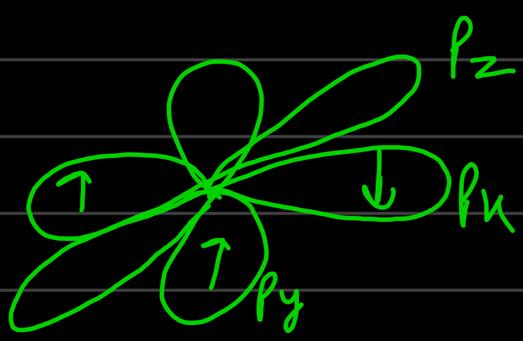
↑↑↑ ↑↓↑ ✗ → From Pauli's rule

↑↓ ↑↓ ↑↓ ✗ → From Hund's rule.

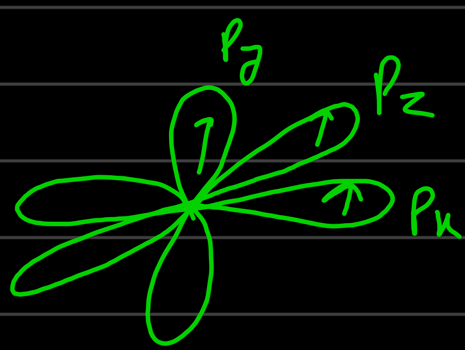
eg:- $3p^3$

↑	↑	↑

↳ reason: Coloumbic repulsions:



higher energy



lower energy

" Electrons would like to be indistinguishable".

↳ they would like to have similar spin.

↳ from exchange interactions

↳ aligned spin angular momentum will lead to intrinsic magnetic momentum.

Curie Temperature: