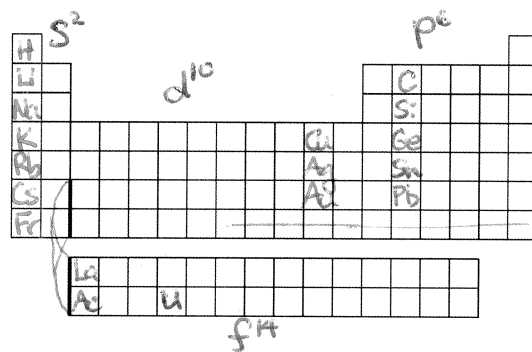
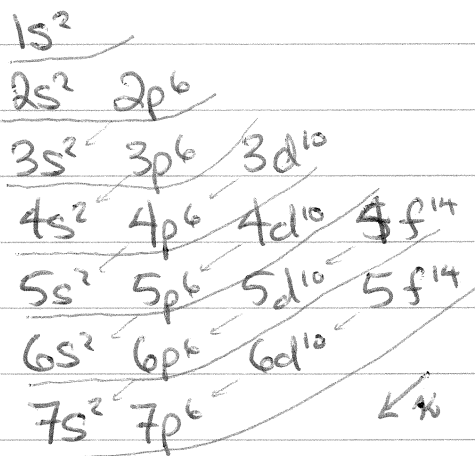


Periodic Table & Spin



* why is there 2 elements for each unique n, l, m ?
 * why is the order screwed up?

Review of L^2

$$\left. \begin{aligned} L^2 &= \hbar^2 l(l+1) \quad l=0,1,2,\dots \\ L_z &= \hbar m \quad m=-l, \dots, 0, \dots, l+1, l \end{aligned} \right\} \begin{array}{l} \text{for angular momentum} \\ \text{waves } Y_{lm}(\theta, \phi). \end{array}$$

* all you need to know - more important than $L^2 = \vec{r} \times \vec{p}$

* for example: $\hat{T} = -\frac{\hbar^2}{2\mu} \nabla^2 = \underbrace{-\frac{\hbar^2}{2\mu} \frac{1}{r} \frac{\partial^2}{\partial r^2} r}_{\frac{p_r^2}{2\mu}} + \frac{1}{2\mu r^2} \left(\frac{\hbar^2}{\sin^2 \theta} \frac{\partial^2}{\partial \phi^2} + \dots \right)$

$\frac{L^2}{2I} = \frac{\hbar^2 l(l+1)}{2\mu r^2}$

Magnetic Interactions

$$\vec{\mu} = -\left(\frac{e}{2m_e}\right) \vec{L}$$

γ gyromagnetic ratio.

$$\mu_B = -1 \cdot \frac{e\hbar}{2m_e} m_l$$

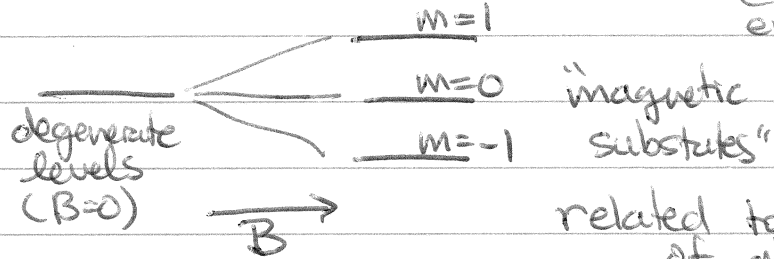
μ_B Bohr magneton.

- 1) $\vec{\tau} = \vec{\mu} \times \vec{B}$
- 2) $U = -\vec{\mu} \cdot \vec{B}$
- 3) $\vec{F} = \nabla(\vec{\mu} \cdot \vec{B})$

- 1) Larmor precession frequency ω_L
 $\frac{d\vec{L}}{dt} = -\gamma \vec{L} \times \vec{B}$
 $\frac{dL}{dt} = \omega_L = \gamma B$

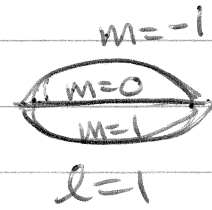
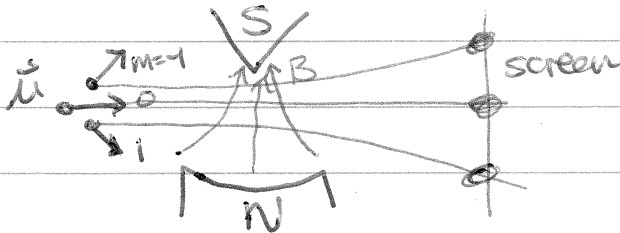
"Nuclear magnetic resonance" (MRI)

2) Zeeman effect. $U = -\vec{\mu} \cdot \vec{B} = \underbrace{g \mu_B B}_{\text{energy shift}} m_l$

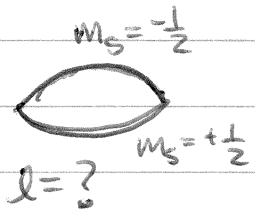


related to "fine structure" of atomic spectra.

3) Stern-Gerlach effect.



3 substates



2 substates.

Evidence of spin:

- 2x degeneracy of periodic table
- fine structure of atomic spectra
- Stern-Gerlach experiment.

$$\begin{cases} S^2 = \hbar^2 s(s+1) & s = \frac{1}{2} \\ S_z = \hbar m_s & m_s = \pm \frac{1}{2} \end{cases}$$

- * same appearance as orbital angular mom
- * fixed total value.

Total angular momentum

$$\vec{J} = \vec{L} + \vec{S} \quad J^2 = L^2 + S^2 + 2(\vec{L} \cdot \vec{S})$$

$$\begin{cases} J^2 = \hbar^2 j(j+1) & j = 0, \frac{1}{2}, 1, \frac{3}{2} \\ J_z = \hbar m & m = -j, \dots, j \end{cases}$$

* same shape.

