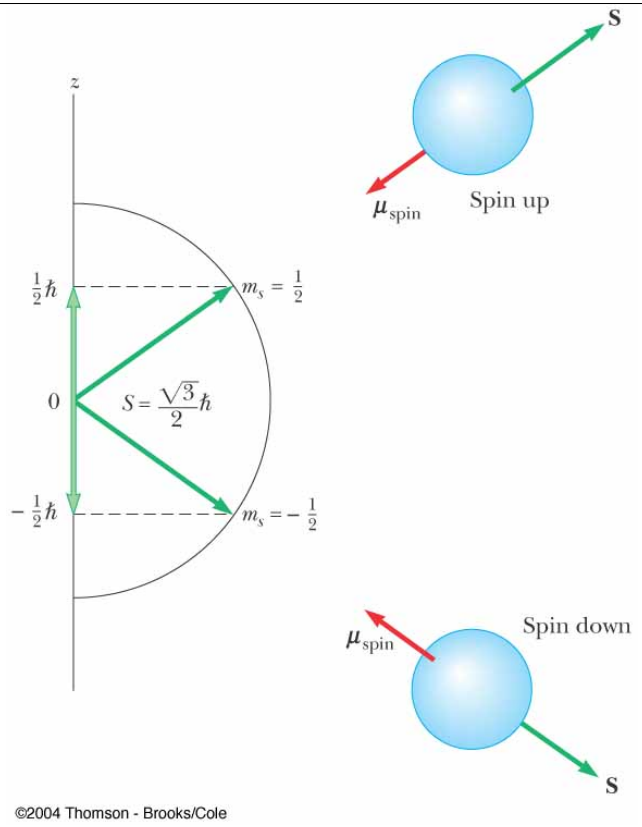
Electron Spin

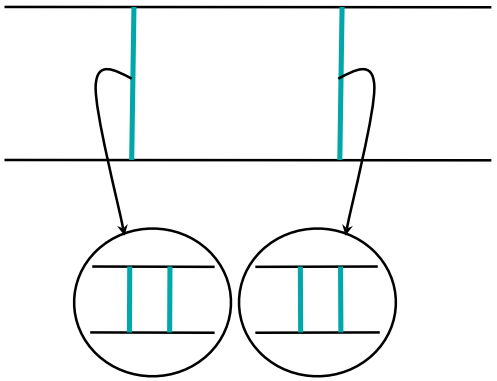
intrinsic quantized angular momentum (spin)

$$S = \sqrt{s(s+1)}\hbar, \left(s = \frac{1}{2} \text{ for electrons} \right)$$

The *z* component of spin angular momentum is $S_z = m_s\hbar = \pm 1/2\ \hbar$

$$m_s = +\frac{1}{2} \text{ or } -\frac{1}{2}$$





- 2 directions exist for electron spins: up and down
- **Fine structure**: spectral lines are doublets even without an external B-field due to interaction of L and S (spin-orbit)
- p and n have spin 1/2, photon has spin 1

Shells and Subshells

Atomic Shell and Subshell Notations			
n	Shell Symbol	ℓ	Subshell Symbol
1	K	0	s
2	L	1	p
3	M	2	d
4	N	3	f
5	O	4	g
6	P	5	h
.		.	

only one electron can be put in each quantum state

E.g. ground state of Hydrogen:

n=1, l=0 is denoted as $1s^1$

There are a total of 8 states with n=2

$l = 0$:

$m_l = 0 : m_s = 0.5 , -0.5$ 2 states

$l = 1$:

$m_l = +1: m_s = 0.5 , -0.5$ 2 states

$m_l = 0: m_s = 0.5 , -0.5$ 2 states

$m_l = -1: m_s = 0.5 , -0.5$ 2 states

Pauli's exclusion principle (1925)

Electrons are indistinguishable but can be labeled with quantum numbers and 2 electrons cannot have the same set of 4 quantum numbers

Allowed Quantum States for an Atom up to $n = 3$

n	1	2				3								
ℓ	0	0	1			0	1			2				
m_ℓ	0	0	1	0	−1	0	1	0	−1	2	1	0	−1	−2
m_s	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅

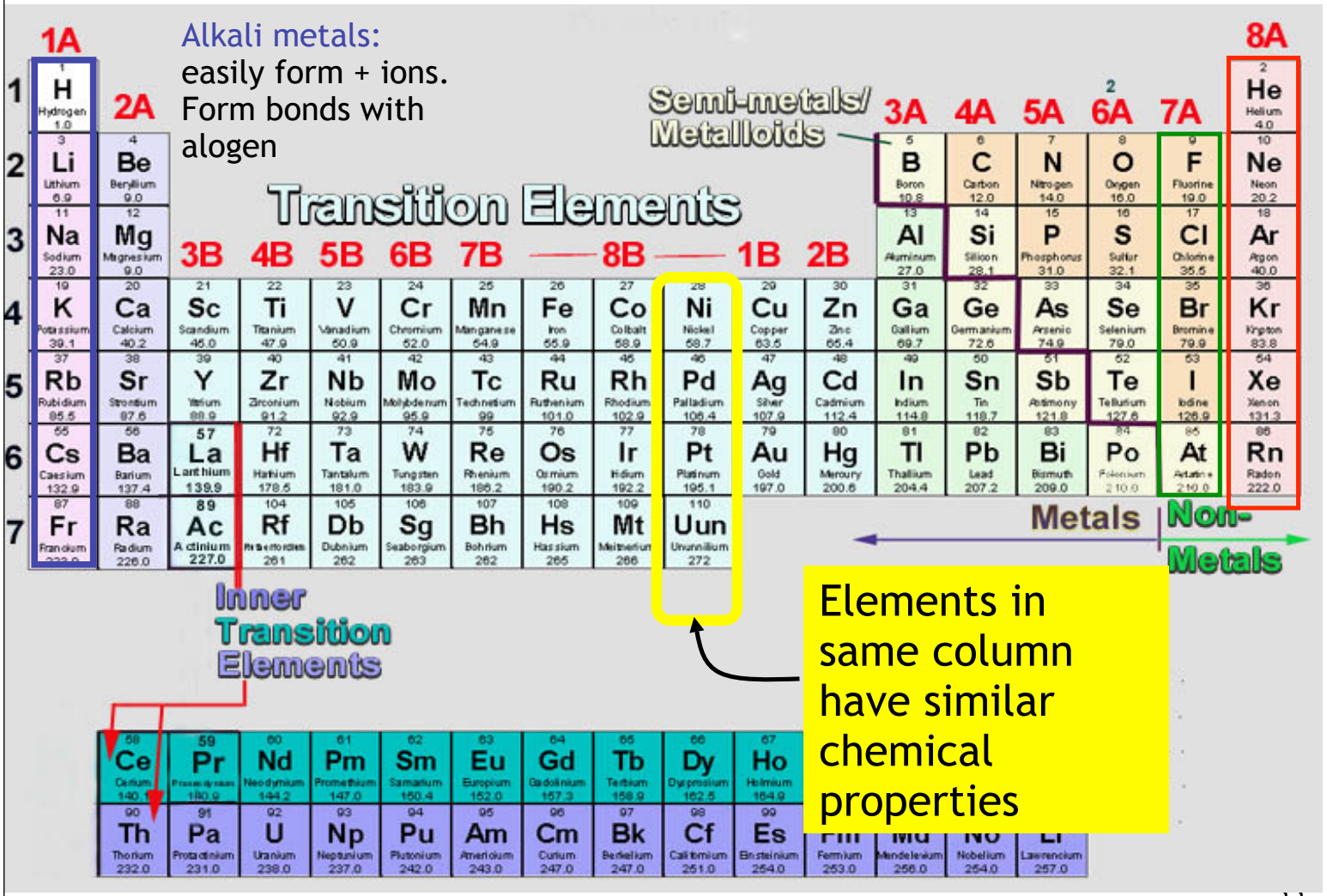
- each shell can accommodate up to $2n^2$ electrons, each subshell 2(2l+1)
- **Hund's rule:** when an atom has orbitals of equal energy, the order in which they are filled by electrons is such that a maximum number of electrons have unpaired spins

Electron Configurations

Atom	Configuration		
H	$1s^1$		
He	$1s^2$	1s shell filled	(n=1 shell filled - noble gas)
Li	$1s^2 2s^1$		
Be	$1s^2 2s^2$	2s shell filled	
B	$1s^2 2s^2 2p^1$		
etc			
Ne	$1s^2 2s^2 2p^6$	2p shell filled	(n=2 shell filled - noble gas)

The Periodic Table

Dmitri Mendeleev: he made predictions about chemical properties of missing elements and within 20 years of the predictions, most of the elements were discovered

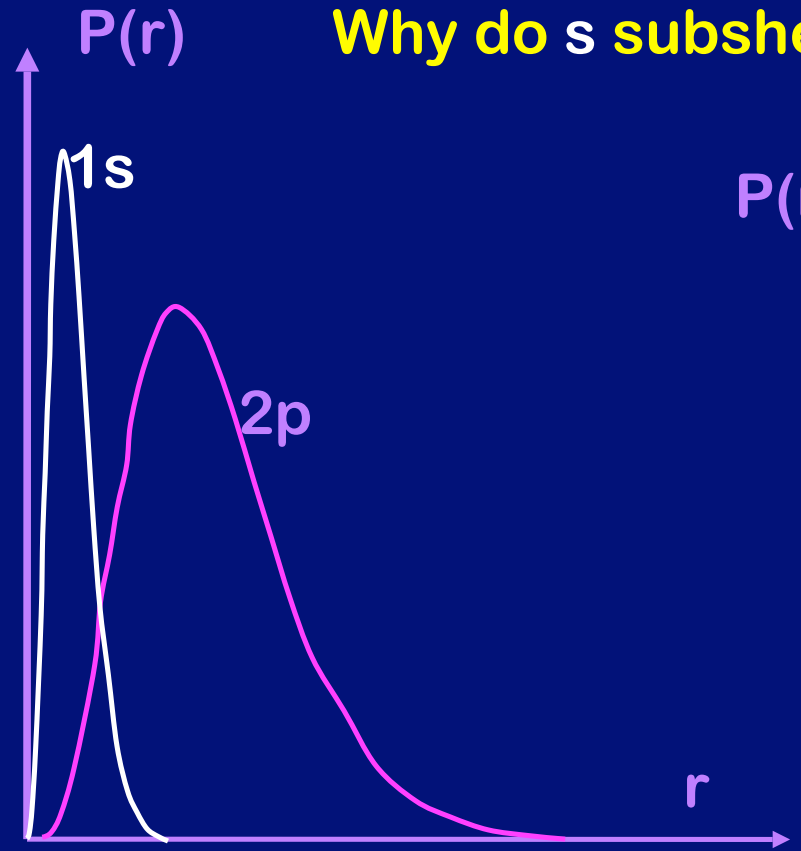


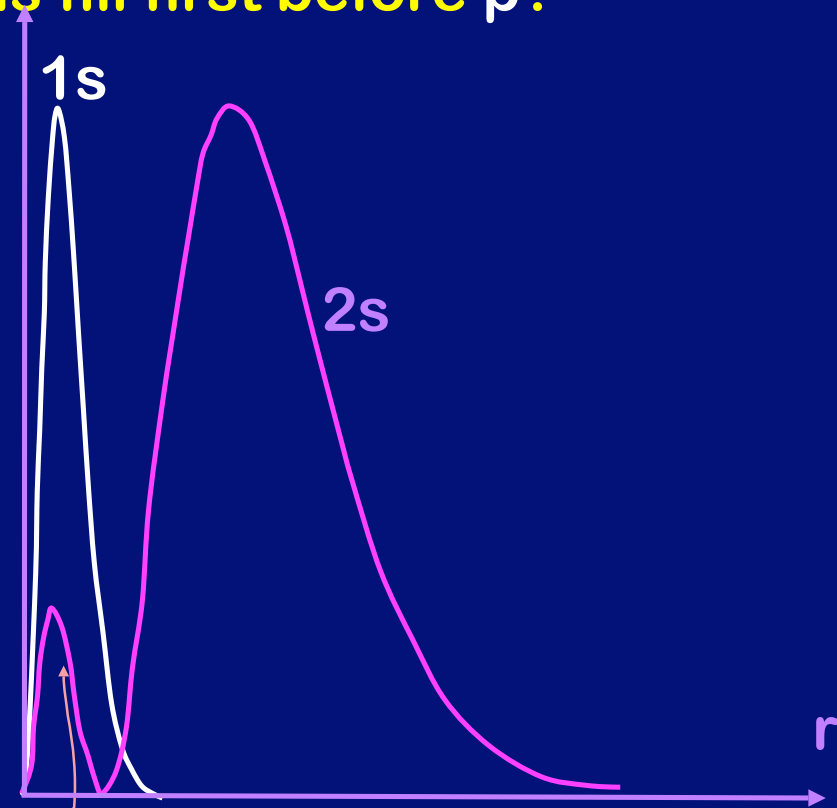
Inert or noble gases: do not join with other atoms to form molecules

Halogens: the outer shell is 1 electron short, they readily accept another electron from another atom

Shell Ordering

Why do s subshells fill first before p?





2s and 2p have the same energy: so this cannot be the reason.
This is a multi-electron interaction effect: 2s electrons can get closer to nucleus, which means less "shielding" from the 1s electrons and stronger attraction to nucleus