Chem 111

Lecture 23

Announcements

- Exam 2 Take Home

Found:
http://people.chem.umass.edu/cjoseph/chem111/

You may turn it early

Can grab a Scantron

Use any written resource or students in class.

You may **NOT** use SI's, Instructors, TA's or ANY OTHER person outside of class, including "web tutors".

Homework

- Start Reading Chapter 7
- Owl Homework

Recap

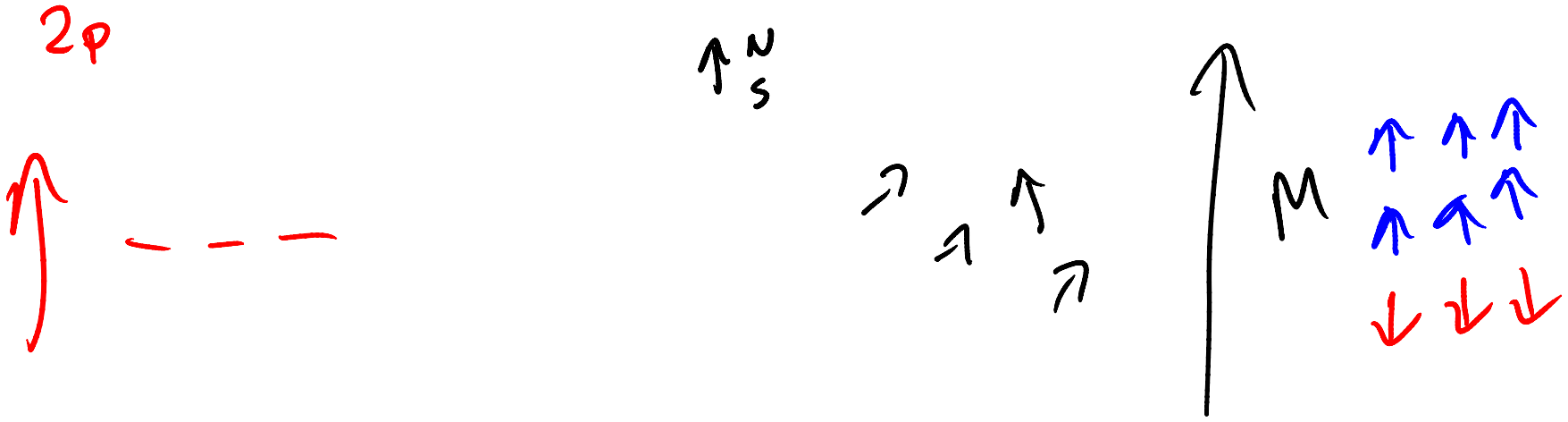
- Quantum numbers
- Degenerate
- Spin

$n =$

$l =$

$m_l =$

$m_s =$



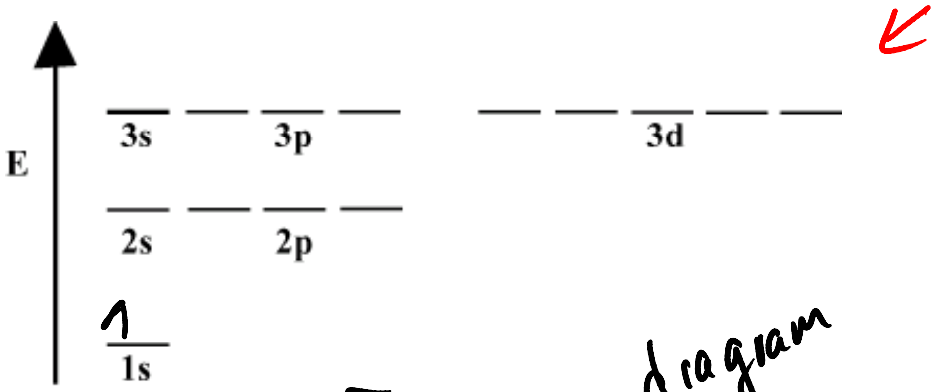
Electron Configuration

H_2

H atomic # 1

- The way in which electrons are distributed among the various orbitals of an atom is called its **electron configuration.**

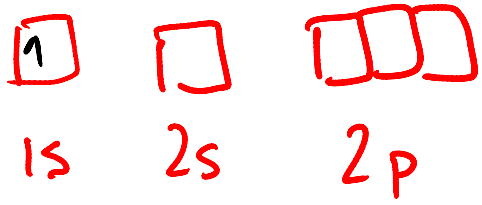
- The most stable, or ground state, electron configuration of an atom is that in which the electrons are in the lowest possible energy state.



Energy diagram

Hydrogen

box diagram →



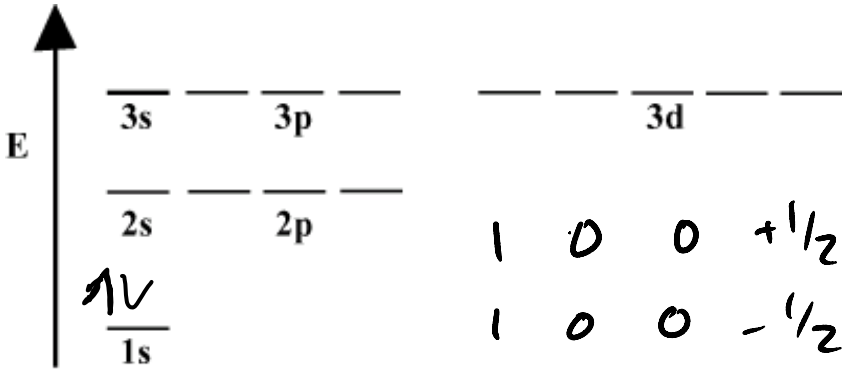
e c → $1s^1$

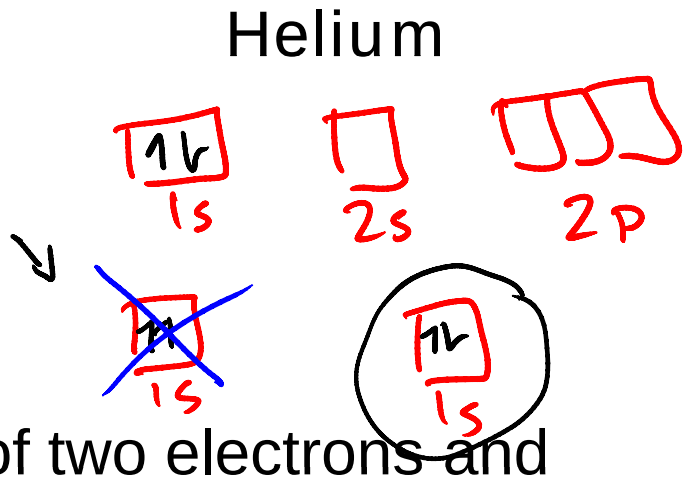
Helium

He atomic # 2

n, l, m_l, m_s

- **Pauli exclusion principle** states that no two electrons in an atom can have the same set of four qauntum numbers (n, ℓ, m_ℓ, m_s)





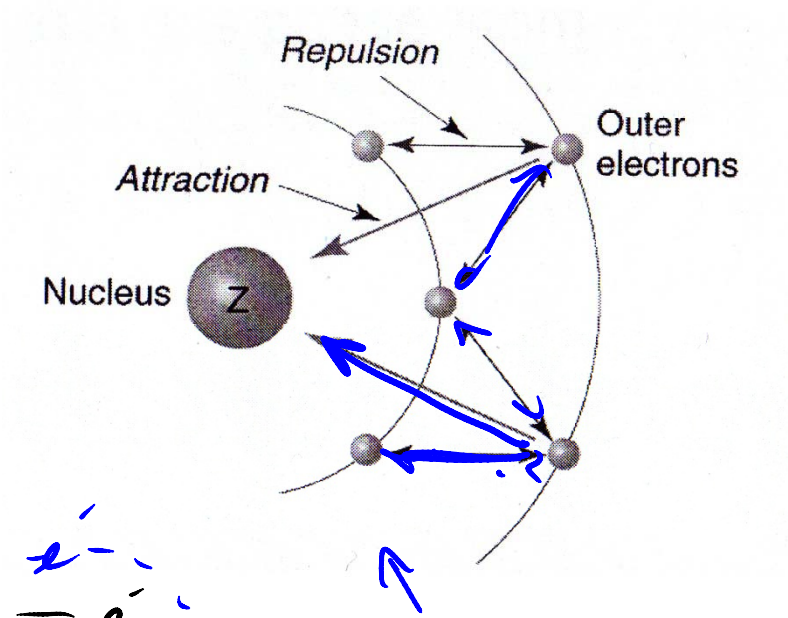
- An orbital can hold a maximum of two electrons and they must have opposite spins

$1s^2$

Li atom # 3

Effective nuclear charge

- $Z_{eff} = Z - \sigma$
- σ : Is the shielding constant



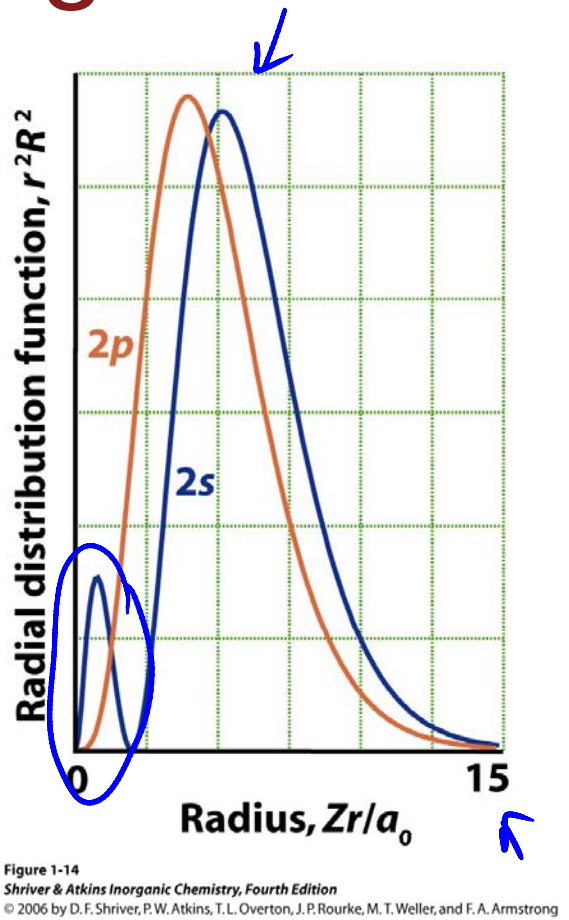
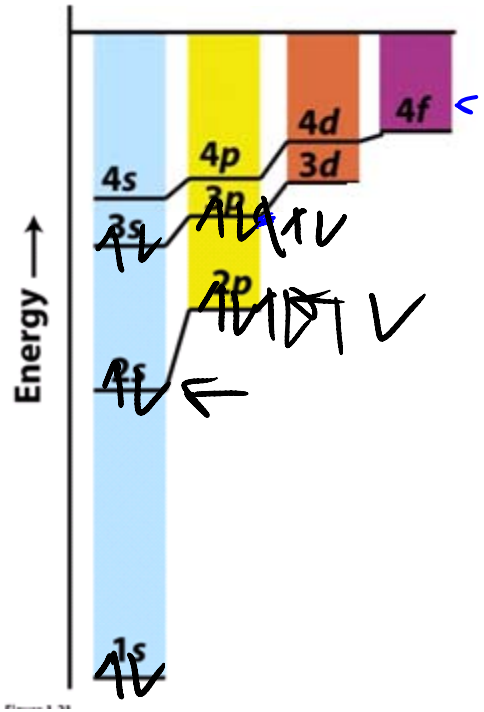


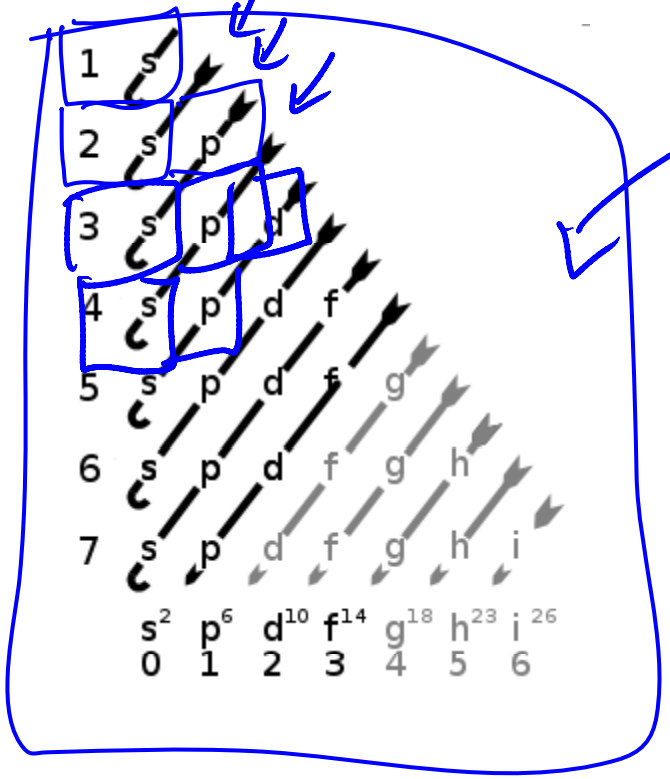
Figure 1-14
Shriver & Atkins Inorganic Chemistry, Fourth Edition

ns<np<nd<nf

Lithium



ns < np < nd



memorize

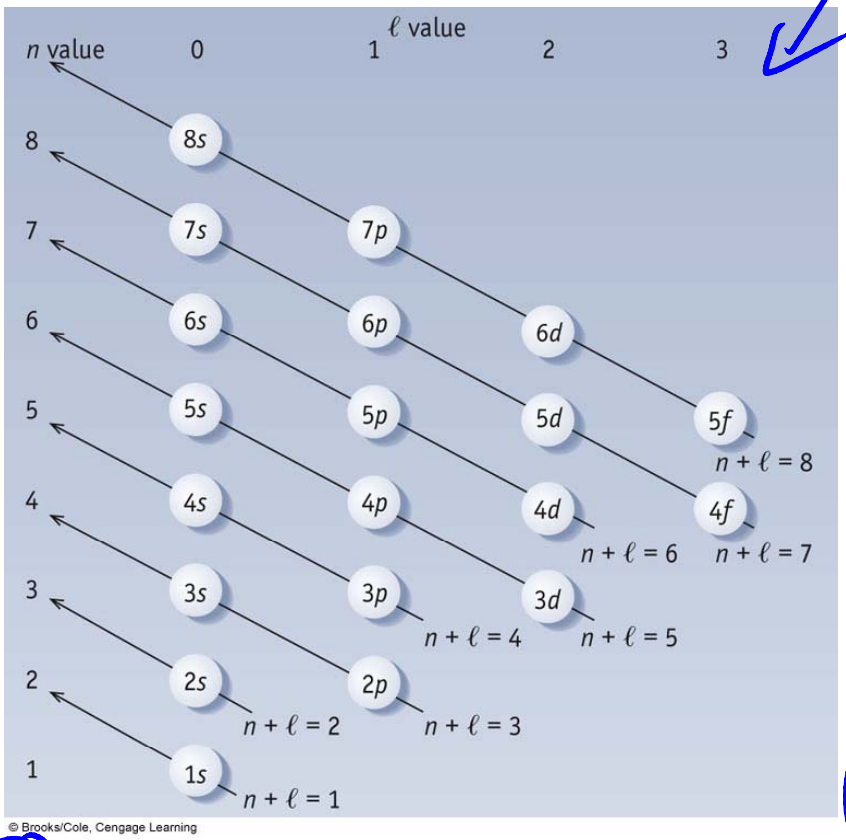
Li atomic #3

$1s^2 2s^1$

→ $1s^2 \rightarrow 2s \rightarrow 2p \rightarrow 3s \rightarrow 3p \rightarrow 4s \rightarrow 3d \rightarrow 4p$

If you are more math inclined

0 = s
1 = p
2 = d



- Electrons are assigned to subshells in the order of increasing "n+ ℓ" value.
- If two subshells with same n+ ℓ" value electrons are assigned to the subshell of lower n.

1s = "n + ℓ" = 1 + 0 = 1

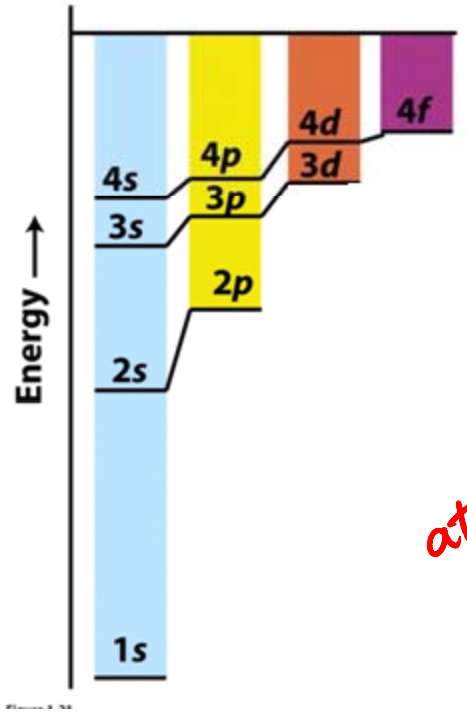
2s = "n + ℓ" = 2 + 0 = 2

2p = "n + ℓ" = 2 + 1 = 3

4s = "n + ℓ" = 4 + 0 = 4

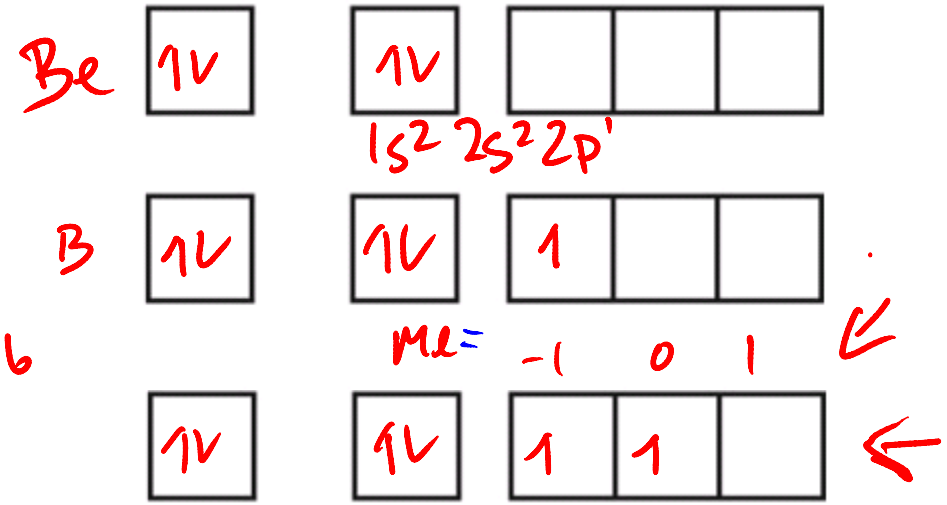
3d = "n + ℓ" = 3 + 2 = 5 ⟷ 4p = "n + ℓ" = 4 + 1 = 5

Carbon



$1s^2\,2s^2\,2p^2$ $1s^2\,1s^2\,2p_x^1\,2p_y^1$

Hund's Rule: for degenerate orbitals, the lowest energy is attained when the number of electrons with the same spin is maximized. $1s^2\,2s^2$



atomic #4 $1s^2\,2s^2\,2p^1$

atomic #5

atomic #6

$m_l = -1 \quad 0 \quad 1$

$-l, \ldots 0, \ldots l$

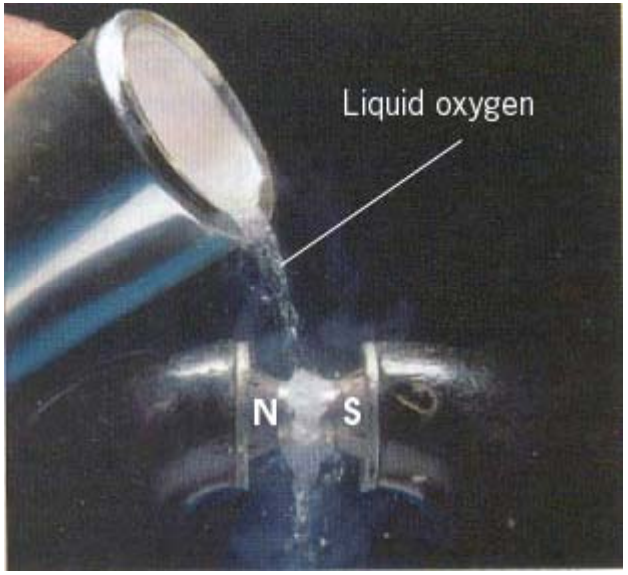
Let’s Practice

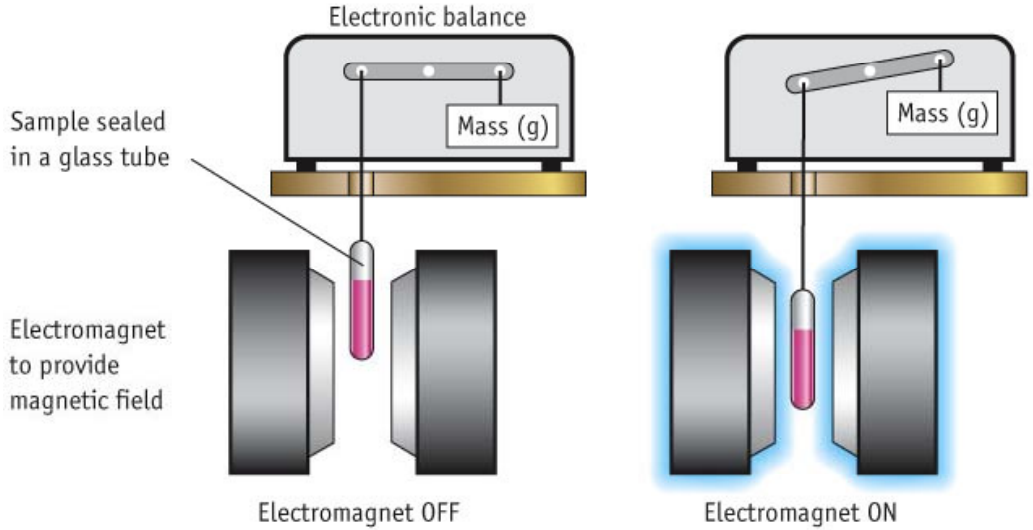
Draw the orbital diagram representation for the electron configuration of oxygen. What is its electron configuration?

Magnetism

Paramagnetism: is caused by the presence of at least one unpaired electron orbital (i.e., an unpaired spin) in the atoms, molecules, or ions. Attracted to magnets.

Diamagnetism: is caused when all electrons are paired. Slightly repulsed by magnets.





(a) Electromagnetic balance

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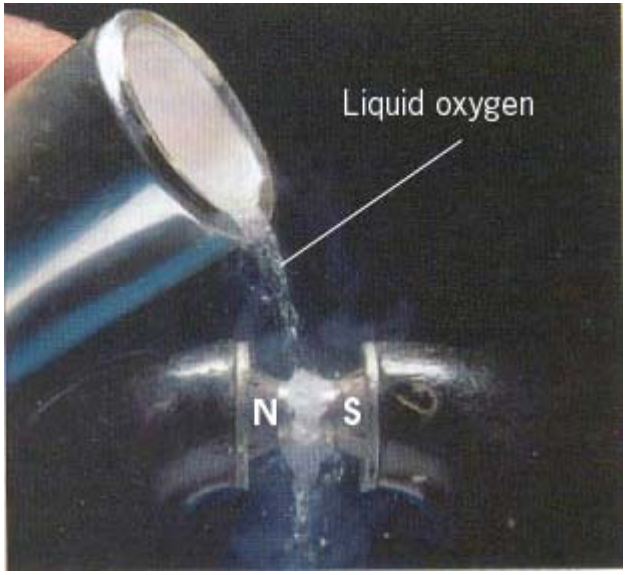
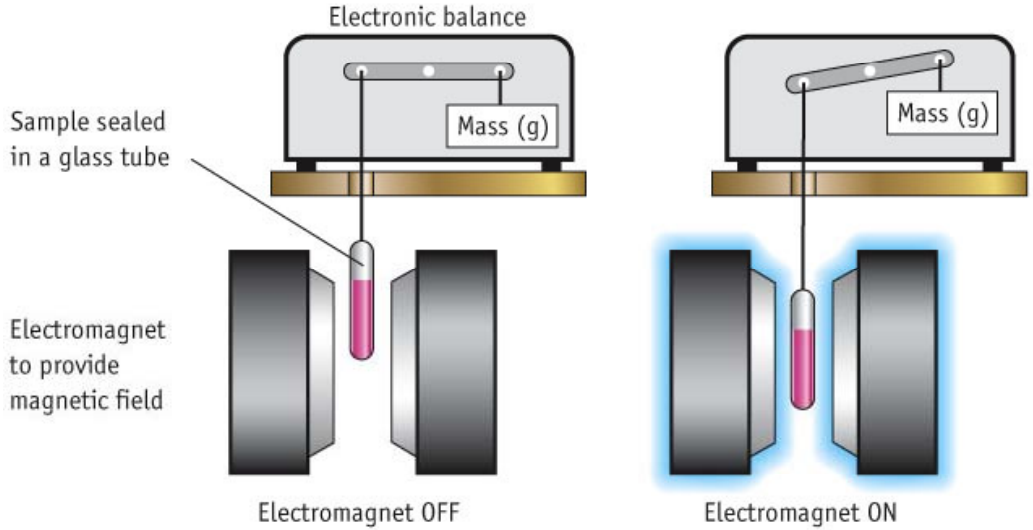


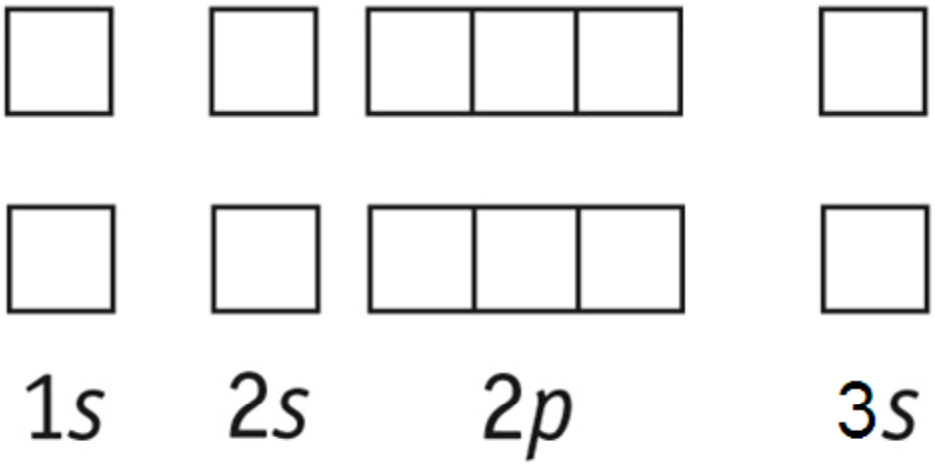


(a) Electromagnetic balance

Neon & Sodium

Valence Electrons: the outer shell electrons

Core Electrons: the inner shell electrons

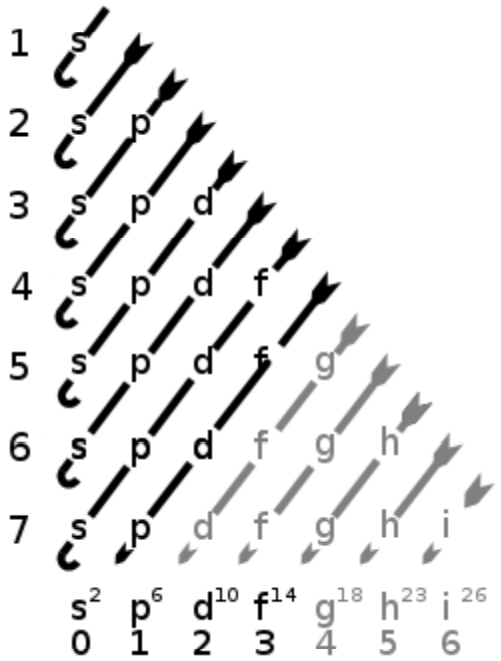


D-block

TABLE 7.4 Orbital Box Diagrams for the Elements Ca Through Zn

		3*d*	4*s*
Ca	[Ar]$4s^2$	☐☐☐☐☐	↑↓
Sc	[Ar]$3d^1 4s^2$	↑☐☐☐☐	↑↓
Ti	[Ar]$3d^2 4s^2$	↑↑☐☐☐	↑↓
V	[Ar]$3d^3 4s^2$	↑↑↑☐☐	↑↓
Cr*	[Ar]$3d^5 4s^1$	↑↑↑↑↑	↑
Mn	[Ar]$3d^5 4s^2$	↑↑↑↑↑	↑↓
Fe	[Ar]$3d^6 4s^2$	↑↓↑↑↑	↑↓
Co	[Ar]$3d^7 4s^2$	↑↓↑↓↑	↑↓
Ni	[Ar]$3d^8 4s^2$	↑↓↑↓↑↓	↑↓
Cu*	[Ar]$3d^{10} 4s^1$	↑↓↑↓↑↓	↑
Zn	[Ar]$3d^{10} 4s^2$	↑↓↑↓↑↓	↑↓

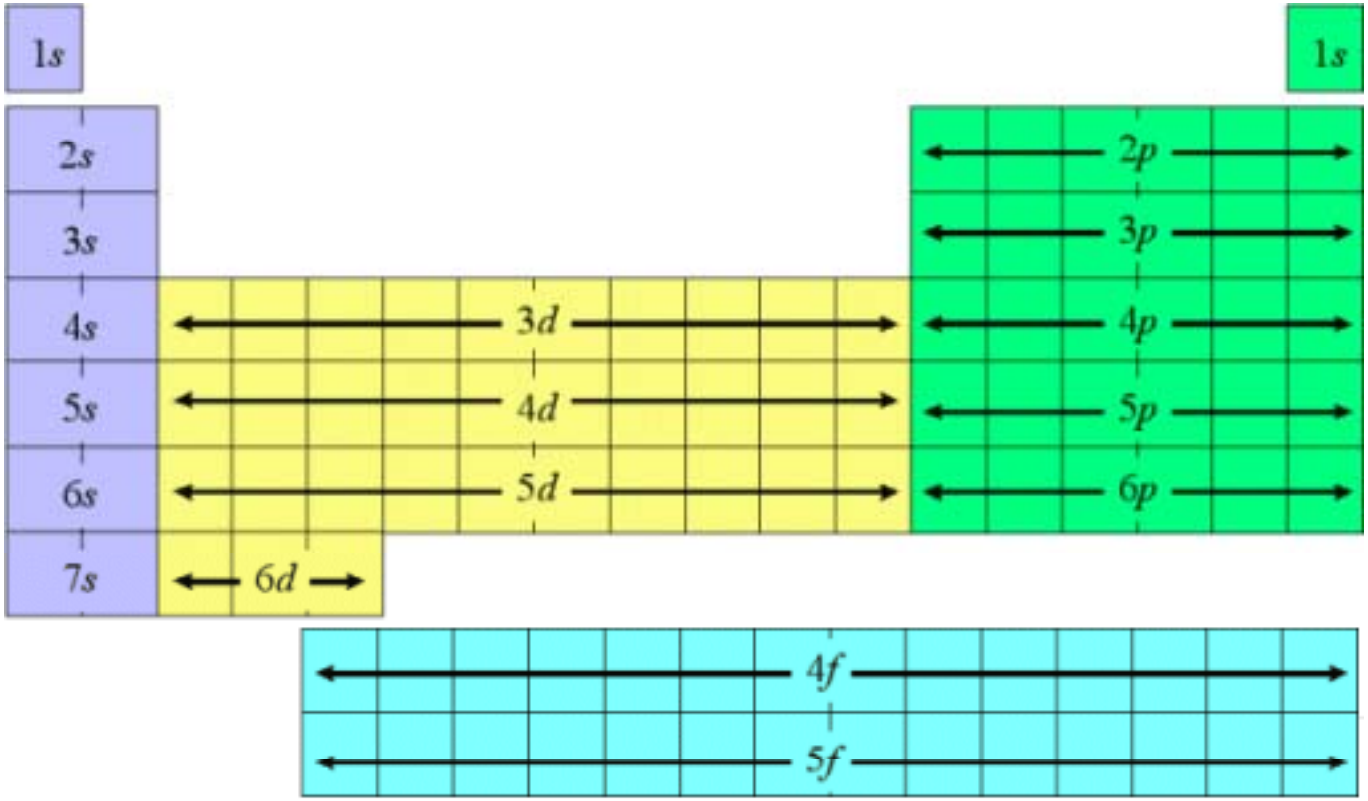
*These configurations do not follow the "$n + \ell$" rule.



Heavy Elements

Element	Z	Electron Configuration	Element	Z	Electron Configuration	Element	Z	Electron Configuration
			Lanthanum	57	[Xe] $6s^2$ $5d^1$	Actinium	89	[Rn] $7s^2$ $6d^1$
			Cerium	58	[Xe] $6s^2$ $4f^1$ $5d^1$	Thorium	90	[Rn] $7s^2$ $6d^2$
			Praseodymium	59	[Xe] $6s^2$ $4f^3$	Protactinium	91	[Rn] $7s^2$ $5f^2$ $6d^1$
			Neodymium	60	[Xe] $6s^2$ $4f^4$	Uranium	92	[Rn] $7s^2$ $5f^3$ $6d^1$
			Promethium	61	[Xe] $6s^2$ $4f^5$	Neptunium	93	[Rn] $7s^2$ $5f^4$ $6d^1$
			Samarium	62	[Xe] $6s^2$ $4f^6$	Plutonium	94	[Rn] $7s^2$ $5f^6$
			Europium	63	[Xe] $6s^2$ $4f^7$	Americium	95	[Rn] $7s^2$ $5f^7$
			Gadolinium	64	[Xe] $6s^2$ $4f^7$ $5d^1$	Curium	96	[Rn] $7s^2$ $5f^7$ $6d^1$
			Terbium	65	[Xe] $6s^2$ $4f^9$	Berkelium	97	[Rn] $7s^2$ $5f^9$
Yttrium	39	[Kr] $5s^2$ $4d^1$	Lutetium	71	[Xe] $6s^2$ $4f^{14}$ $5d^1$	Lawrencium	103	[Rn] $7s^2$ $5f^{14}$ $7p^1$
Zirconium	40	[Kr] $5s^2$ $4d^2$	Hafnium	72	[Xe] $6s^2$ $4f^{14}$ $5d^2$	Rutherfordium	104	*(unknown)*
Niobium	41	[Kr] $5s^1$ $4d^4$	Tantalum	73	[Xe] $6s^2$ $4f^{14}$ $5d^3$			
Molybdenum	42	[Kr] $5s^1$ $4d^5$	Tungsten	74	[Xe] $6s^2$ $4f^{14}$ $5d^4$			
Technetium	43	[Kr] $5s^2$ $4d^5$	Rhenium	75	[Xe] $6s^2$ $4f^{14}$ $5d^5$			
Ruthenium	44	[Kr] $5s^1$ $4d^7$	Osmium	76	[Xe] $6s^2$ $4f^{14}$ $5d^6$			
Rhodium	45	[Kr] $5s^1$ $4d^8$	Iridium	77	[Xe] $6s^2$ $4f^{14}$ $5d^7$			
Palladium	46	[Kr] $4d^{10}$	Platinum	78	[Xe] $6s^1$ $4f^{14}$ $5d^9$			
Silver	47	[Kr] $5s^1$ $4d^{10}$	Gold	79	[Xe] $6s^1$ $4f^{14}$ $5d^{10}$			
Cadmium	48	[Kr] $5s^2$ $4d^{10}$	Mercury	80	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$			
Indium	49	[Kr] $5s^2$ $4d^{10}$ $5p^1$	Thallium	81	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^1$			

Periodic Table… again



Let’s Practice

What is the characteristic outer shell electron configuration of the group 7A elements, the halogens?