ELECTRON CONFIGURATIONS

- ELECTRON CONFIGURATIONS, ORBITAL DIAGRAMS, AUFBAU PRINCIPLE, HUND'S RULE

REPRESENTING ELECTRONS …

- Now that you know what an orbital is, you need to be able to use that to describe the electronic nature of an element
- Two ways:
  - Electron configuration is a **concise** way to describe where the electrons are with respect to energy level and sublevel
  - Orbital diagrams are a **visual way** to describe where the electrons are with respect to energy level and sublevel

ELECTRON CONFIGURATIONS

- With BR diagrams, you could say how many electrons are in each shell

- With electron configurations, you can now say not just what **shell** the electrons are in, but also what **sublevel (s, p, d, f)** they are in as well.

$$2p^4$$

Energy Level

Sublevel

Number of electrons in the sublevel

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4$

AUFBAU PRINCIPLE

- Aufbau described the filling order of the orbitals (ie what order do the electrons go in)
- He said they must be filled from **lowest energy** to **highest energy**
- Like in BR diagrams, you filled the first shell before you moved on to the second shell…but it gets more complicated!
- Sadly, they don't go numerically: 4S is lower in energy than 3D!

LINK TO QUANTUM

- How do we know how many **sublevels** there are in a shell?
- For example, what **sublevels** exist for first shell (n=1)?
  - when n=1, ℓ=0 ONLY so **1s** is the only sublevel
- What about when n=2?
  - ℓ=0 or 1 2s and 2p exist
- What about when n=3?
  - ℓ=0 or 1 or 2 3s and 3p and 3d exist

DIAGONAL RULE

- The diagonal rule is a ***memory device*** that helps you remember the order of the filling of the orbitals from lowest energy to highest energy
- You won't be given this on your exam!

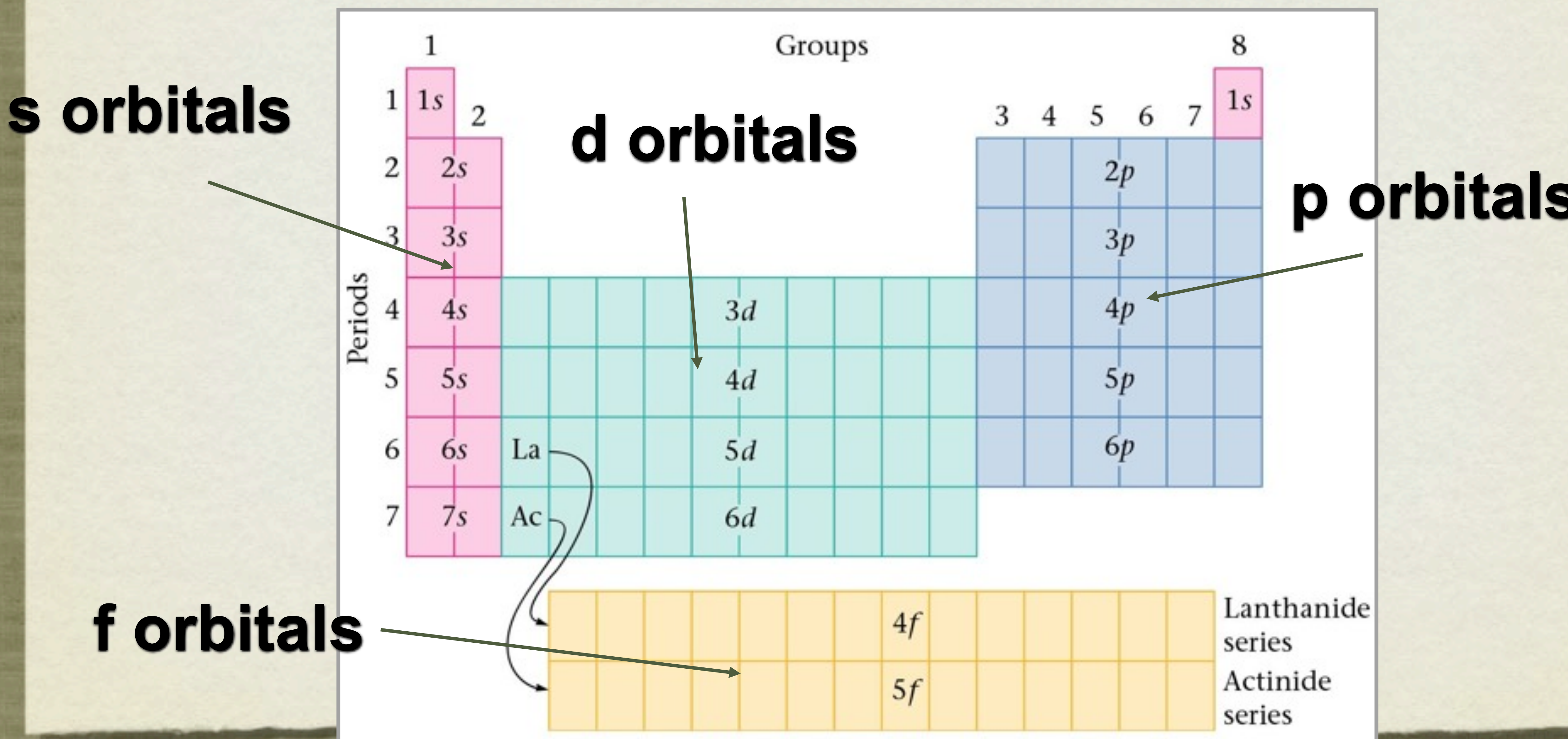
Steps:

1. Write the energy levels top to bottom.
2. Write the orbitals in s, p, d, f order. Write th
   same number of orbitals as the energy level
3. Draw diagonal lines from the top right to the
   bottom left.
4. To get the correct order,
   follow the arrows!

By this point, we are past the current periodic table so we can stop.

ORBITALS & THE PERIODIC TABLE

- Orbitals grouped in s, p, d, and f orbitals
- Knowing the blocks is up to you!



ELECTRON CONFIGURATIONS

Guidelines for "Filling" Orbitals

1. Place electrons into the orbitals in order of increasing energy level.
2. Each set of orbitals of the same energy level must be completely filled before proceeding to the next orbital or series of orbitals.
3. Whenever electrons are added to orbitals of the same energy sub-level, each orbital receives one electron before any pairing occurs.
4. When electrons are added singly to separate orbitals of the same energy, the electrons must all have the same spin.

How many electrons can be in a sublevel?

Remember: A maximum of two electrons can be placed in an orbital.

	s orbitals	p orbitals	d orbitals	f orbitals
Number of orbitals	1	3	5	7
Number of electrons	2	6	10	14

ELECTRON CONFIGURATIONS

$$2p^4$$

Energy Level

Sublevel

Number of electrons in the sublevel

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6$

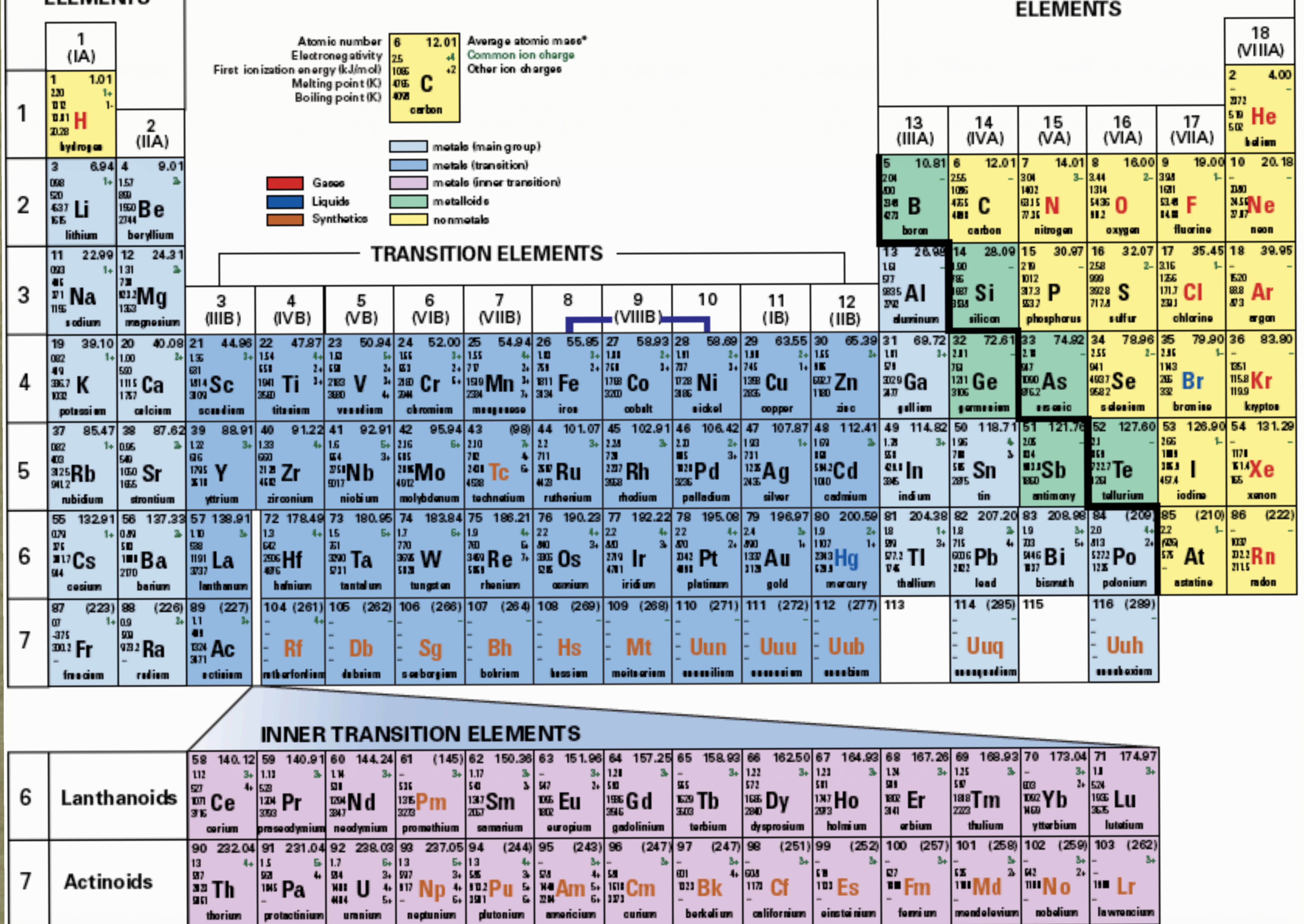
$6s^2\ 4f^{14}$… etc.

LET'S TRY IT!

- Write the electron configuration for the following elements:

H	F
Li	Cr
N	Ne

Periodic Table of the Elements



*Average atomic mass data in brackets indicate atomic mass of most stable isotope of the element.

SHORTHAND NOTATION

- A way of abbreviating long electron configurations
- Since we are only concerned about the outermost electrons, we can skip to places we know are completely full, i.e. the noble gases , and then finish the configuration

SHORTHAND NOTATION

- Step 1: Find the closest noble gas to the atom (or ion), WITHOUT GOING OVER the number of electrons in the atom (or ion). It will be at the end of the period above the element that you are working with Write the noble gas in brackets [ ].
- Step 2: Find where to resume by finding the next energy level.
- Step 3: Resume the configuration until it's finished.

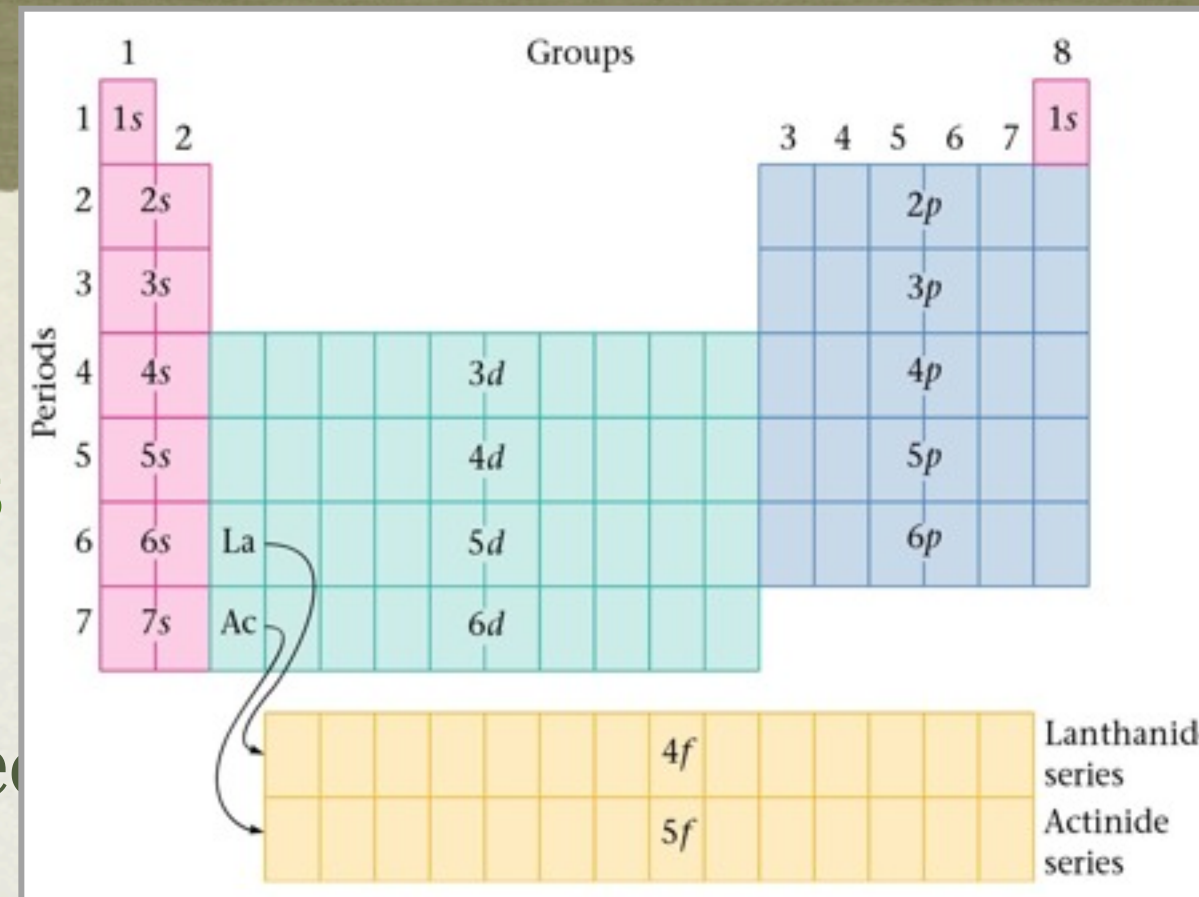
SHORTHAND NOTATION

- **Chlorine**
  - Longhand is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

You can abbreviate the first 10 electrons with a noble gas, Ne
[Ne] replaces $1s^2\ 2s^2\ 2p^6$

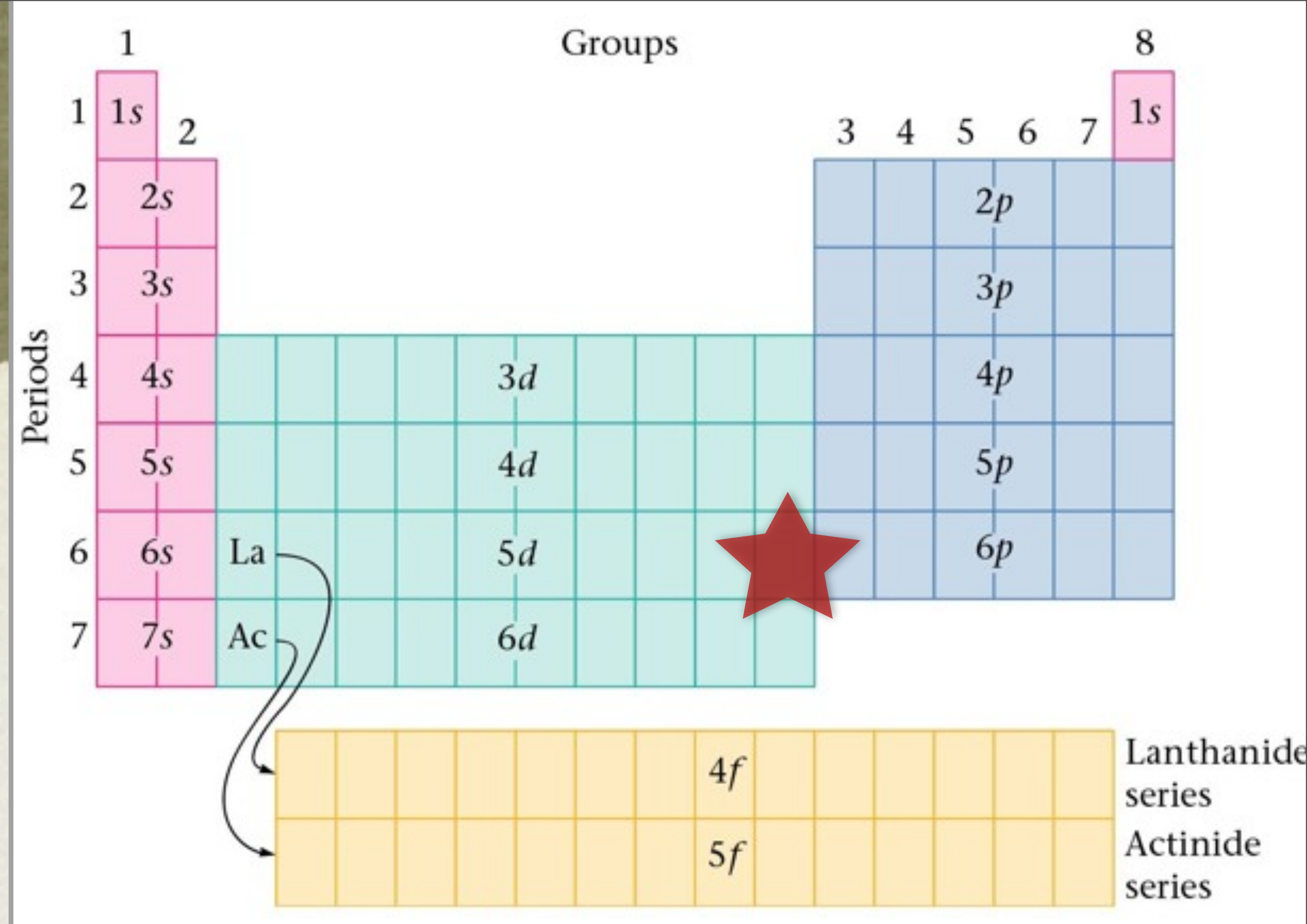
The next energy level after Neon is 3

So you start at level 3 on the diagonal rule (all levels start with s) and finish the configuration by adding 7 more electrons to bring the total to 17



$[Ne]\ 3s^2\ 3p^5$

F BLOCK



Any element past #57 will have f block electrons

Let's try Hg (#80)

[Xe] $6s^2 4f^{14} 5d^{10}$

PRACTICE SHORTHAND NOTATION

- Write the shorthand notation for the following atoms:

S

K

Ca

I

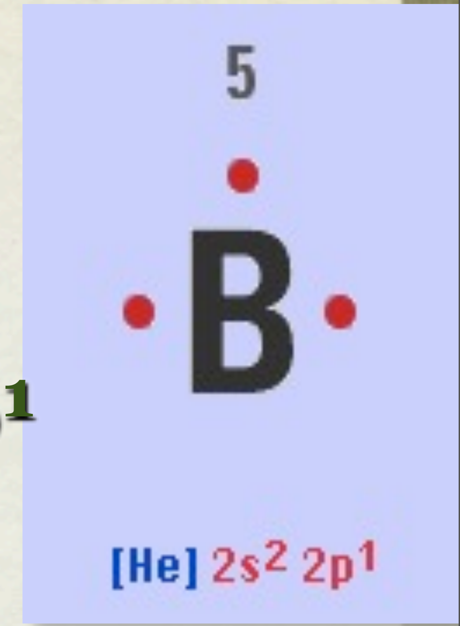
Bi

VALENCE ELECTRONS

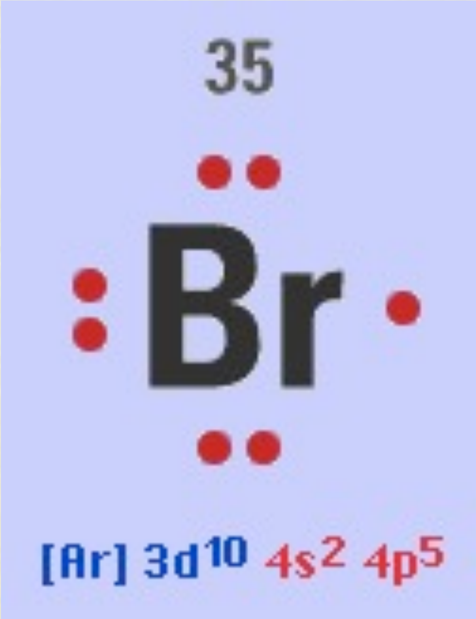
Electrons are divided between core & valence electrons

Write the electron configuration of Boron and determine how many valence electrons Boron has

B $1s^2$ $2s^2$ $2p^1$ Core = [He] **Valence =** $2s^2$ $2p^1$



Write the electron configuration of Bromine and determine how many valence electrons Br has



Br [Ar] $4s^2$ $3d^{10}$ $4p^5$

Core = [Ar] $3d^{10}$, **valence =** $4s^2$ $4p^5$

VALENCE ELECTRONS

- Valence electrons are always found in the OUTERMOST shell.
- It doesn't matter in the order they are written in!
- Always the shell with the highest principal number

How many valence electrons?

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ 8 ve

KEEP AN EYE ON THOSE IONS!

- Electrons can be lost or gained by atoms to form ions
- negative ions have gained electrons, positive ions have lost electrons
- The electrons that are lost or gained should be added/removed from the ***<u>highest energy level</u>*** (not the highest orbital in energy!)

FORMING IONS!

- Write electron configurations: Sn, Sn^{2+}, Sn^{4+}

<u>Atom:</u> [Kr] $5s^2\ 4d^{10}\ 5p^2$

<u>Sn^{+2} ion:</u> [Kr] $5s^2\ 4d^{10}$

<u>Sn^{+4} ion:</u> [Kr] $4d^{10}$

Note that the electrons came out of the highest energy level, not the highest energy orbital!

FORMING IONS

- Bromine

<u>Atom:</u> [Ar] $4s^2\ 3d^{10}\ 4p^5$

<u>Br^- ion:</u> [Ar] $4s^2\ 3d^{10}\ 4p^6$

Note that the electrons went into the highest energy level, not the highest energy orbital!

TRY SOME IONS!

- Write the longhand notation for these:

F^-

Li^+

Mg^{+2}

Write the shorthand notation for these:

Ba^{+2}

Al^{+3}

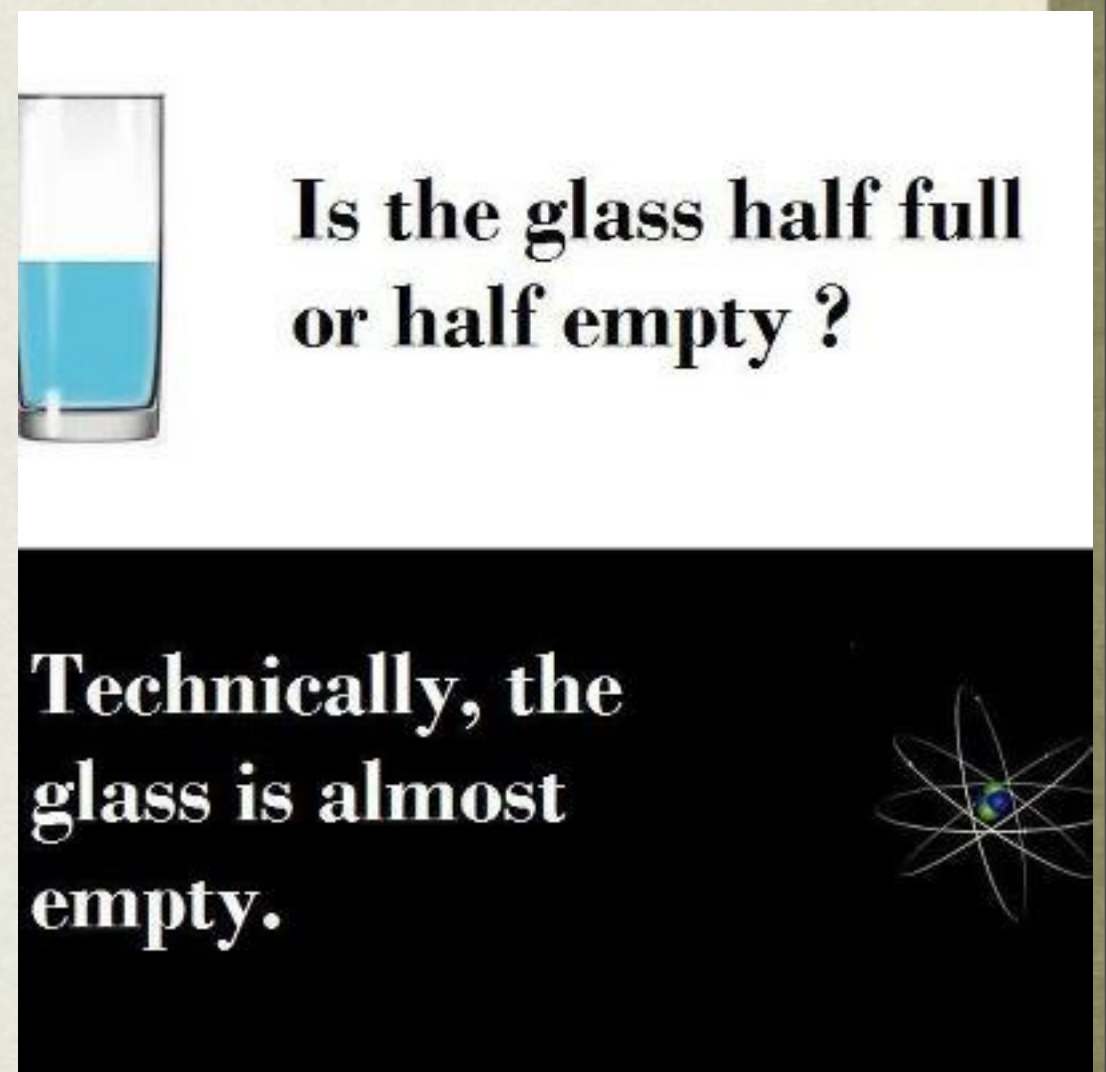
HOMEWORK

- Complete all of p.40 in your workbook

EXCEPTIONS TO THE AUFBAU PRINCIPLE

- Remember d and f orbitals require LARGE amounts of energy
- If we can't fill these sublevels, then the next best thing is to be **HALF** full (**one electron in each orbital in the sublevel)**
- There are many exceptions, but the most common ones are

d^4 and d^9



$d^4 \longrightarrow d^5$

- d orbitals can hold up to 10 electrons so ...d^4 is one electron short of being HALF full (d^5)

- In order to become more stable (require less energy), one of the **closest** s electrons will actually go into the d, making it d^5 instead of d^4.

Write electron configuration of Cr

[Ar] $4s^2\ 3d^4$

Procedure: Find the closest s orbital. Steal one electron from it, and add it to the d.

[Ar] $4s^1\ 3d^5$

$d^9 \longrightarrow d^{10}$

- d^9 is one electron short of being full
- Just like d^4, one of the ***closest s*** electrons will go into the d, this time making it d^{10} instead of d^9.

Write electron configuration of Au   [Xe] $6s^2\ 4f^{14}\ 5d^9$

<u>Procedure:</u> Find the closest s orbital. Steal one electron from it, and add it to the d.

[Xe] $6s^1\ 4f^{14}\ 5d^{10}$

TRY THESE!

- Write the longhand notation for:

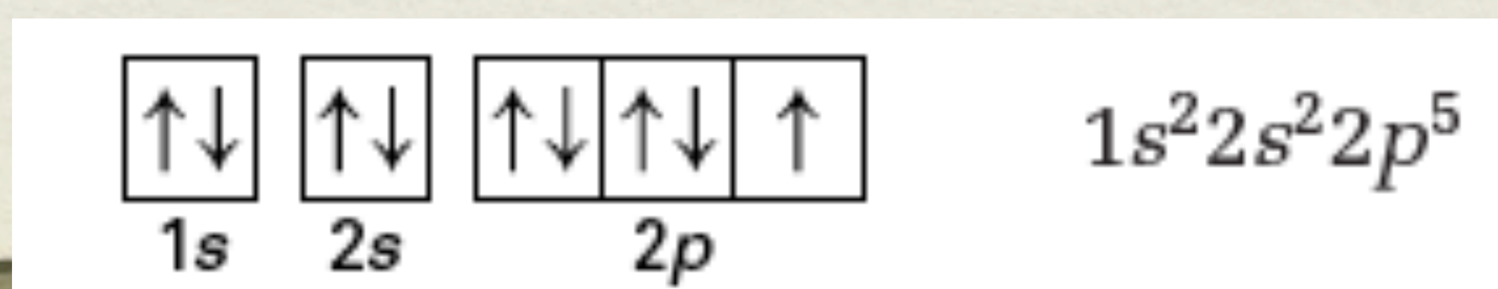
Cu $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

Cr $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

Mo $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^5 5s^1$

ORBITAL DIAGRAMS

- Graphical representation of an electron configuration
- One arrow represents one electron
- Shows spin and which orbital within a sublevel
- Same rules as before (Aufbau principle, d^4 and d^9 exceptions, two electrons in each orbital, etc. etc.)



HUND'S RULE

- In orbitals of EQUAL ENERGY (p, d, and f), place one electron in each orbital before making any pairs

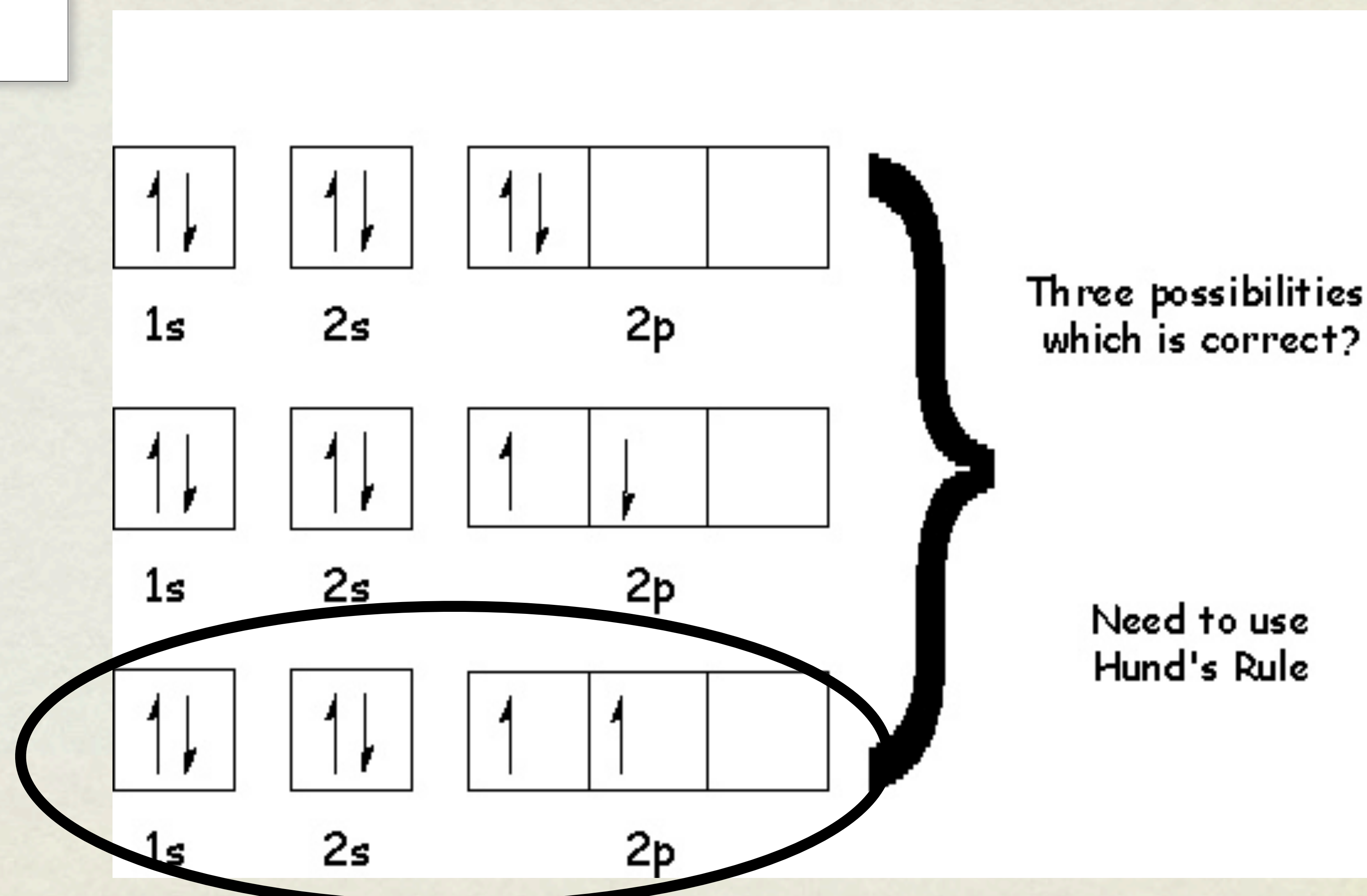
- All single electrons must spin the same way

- Think of this rule as the "Monopoly Rule"

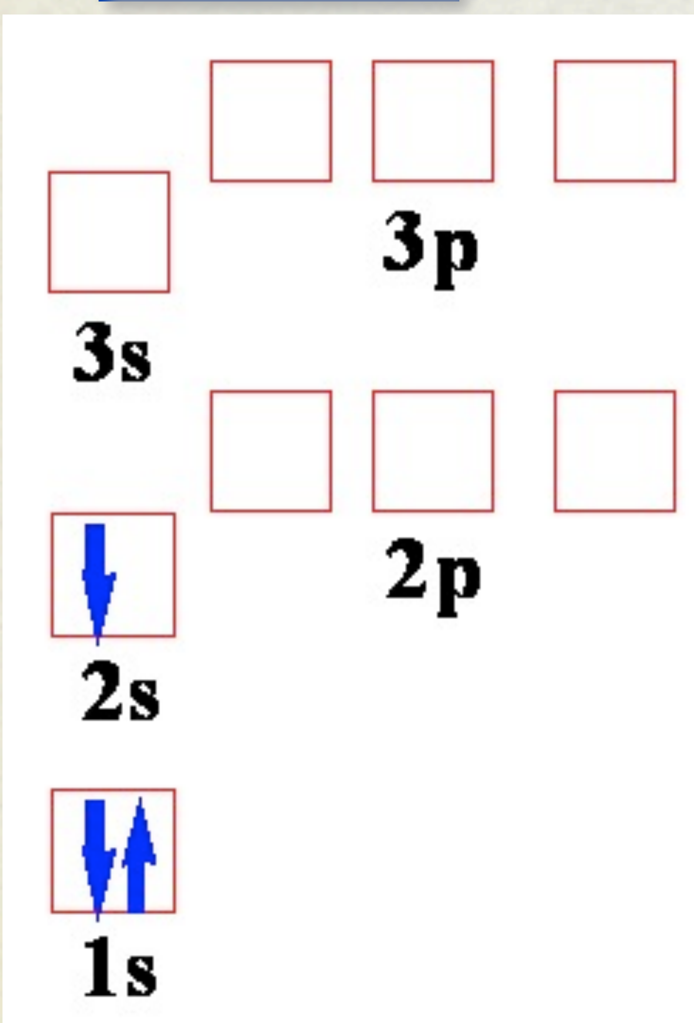
- In Monopoly, you have to build houses EVENLY. You can not put 2 houses on a property until all the properties has at least 1 house.

CARBON

$1s^2\ 2s^2\ 2p^2$ ---> 6 total electrons



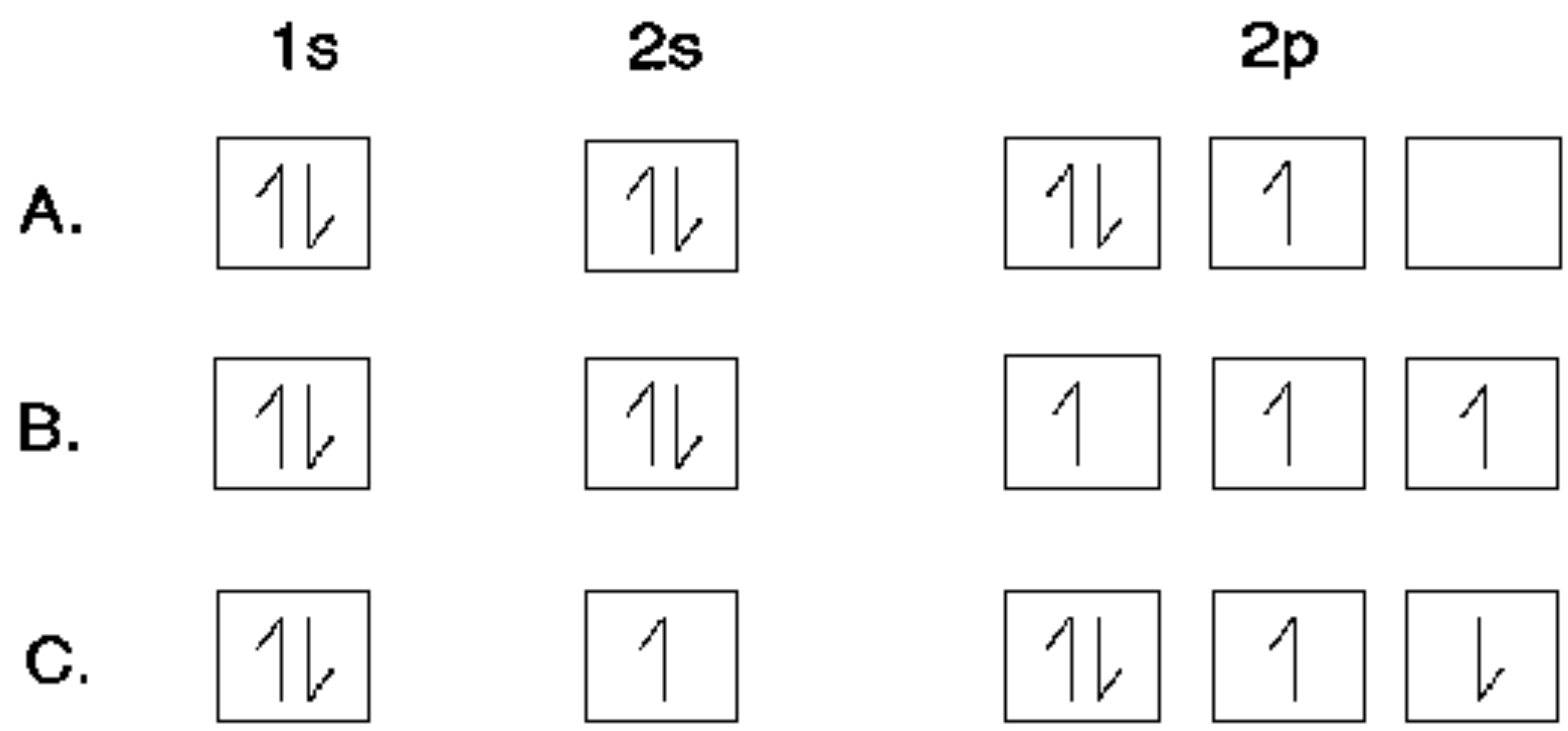
LITHIUM



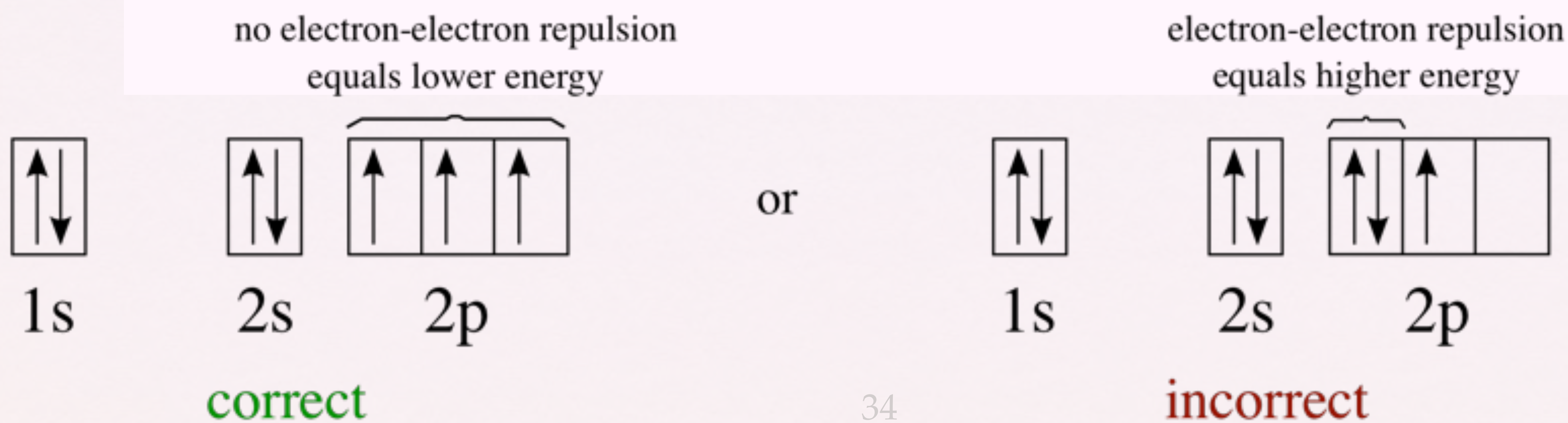
Electron configuration:

$1s^2 2s^1$ ---> 3 total electrons

NITROGEN

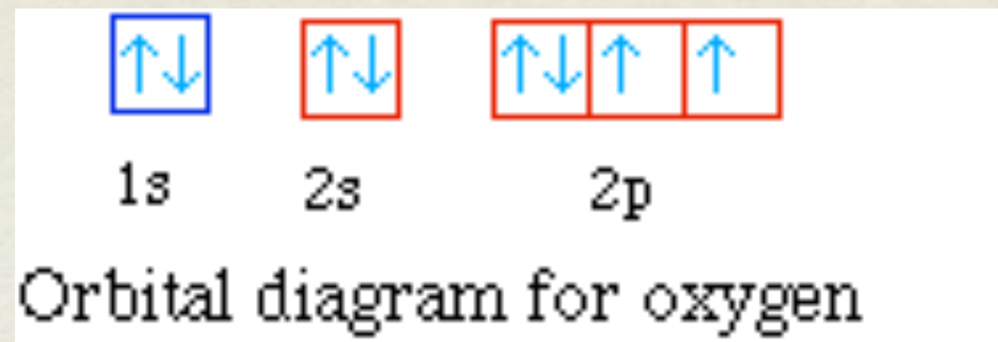


D. Both (A) and (C) are correct.

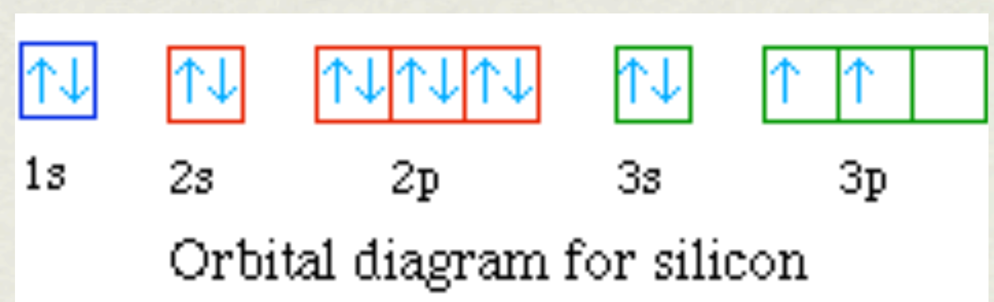


DRAW THESE ORBITAL DIAGRAMS!

- Oxygen (O)



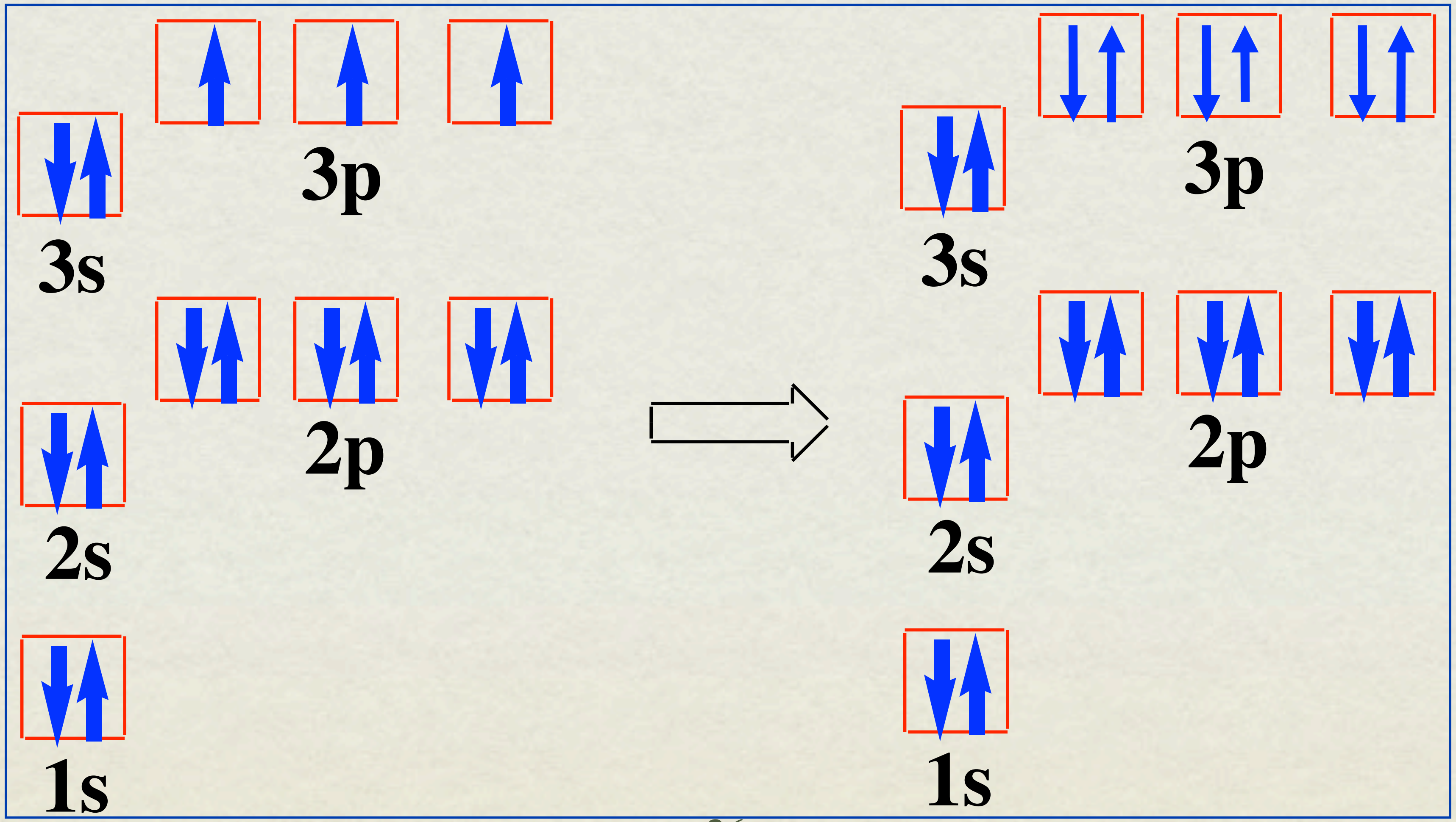
- Silicon (Si)



IONS!

To form anions from elements, add 1 or more e- from the highest sublevel.

P [Ne] $3s^2$ $3p^3$ + 3e- ---> P^{3-} [Ne] $3s^2$ $3p^6$ or [Ar]



TRY IT!

Element	Total number of electrons	Orbital diagram 1s 2s 2p 3s	Full Electron configuration
Helium	2		
Lithium	3		
Boron	5		
Nitrogen	7		
Fluorine	9		
Sodium	11		s^1

TRY IT!

- ✓ P.191 #3,4
  P.194 # 6,8,9,10