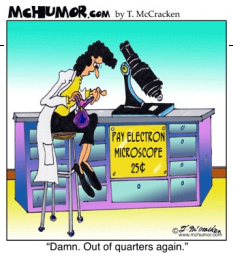
Electrons in Atoms



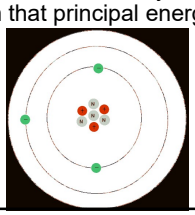
"Damn. Out of quarters again."

Quantum Theory

EQ: What is the relationship between energy levels and sublevels?

A. Vocabulary

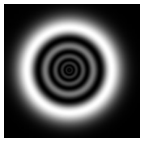
1. Principal Quantum Number (n) = major energy level (rows in P-Table)
2. Sublevels: Electron energy levels within a principal energy level (aka: Shapes)
   1. The "n" number also tells you how many shapes are held in that principal energy level

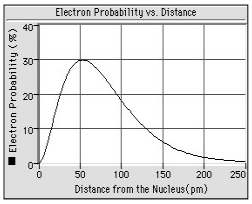


A. Vocabulary

3. Atomic Orbital (electron cloud): Region in space where there is 90% probability of finding an e^-

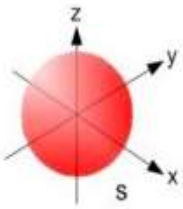
a) each orbital can hold 2 electrons





Radial Distribution Curve

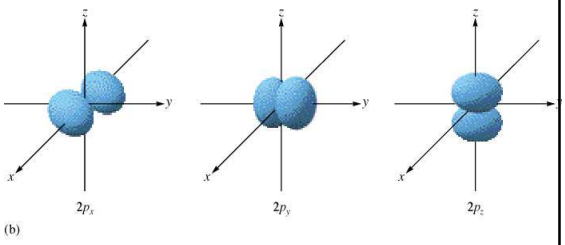
S orbital



B. Sublevel Shapes

sublevel	Shape	# of orbitals	# of e-
s	sphere	1	2
p			
d			
f			

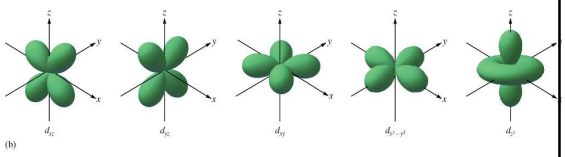
P orbitals



B. Sublevel Shapes

sublevel	Shape	# of orbitals	# of e-
s	**sphere**	**1**	**2**
p	**peanut**	**3**	**6**
d			
f			

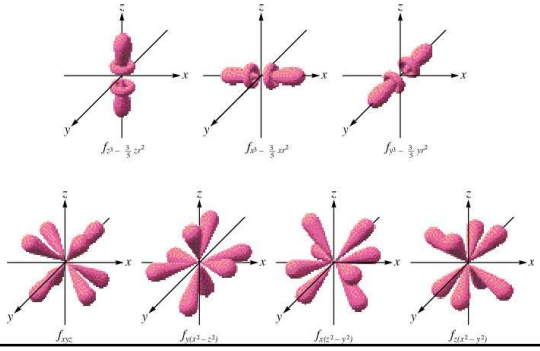
D orbitals



B. Sublevel Shapes

sublevel	Shape	# of orbitals	# of e-
s	**sphere**	**1**	**2**
p	**peanut**	**3**	**6**
d	**Double peanut**	**5**	**10**
f			

F orbitals



B. Sublevel Shapes

sublevel	Shape	# of orbitals	# of e-
s	**sphere**	**1**	**2**
p	**peanut**	**3**	**6**
d	**Double peanut**	**5**	**10**
f	**flower**	**7**	**14**

C. Sublevels and "n"

- The # of energy levels tells you how many sublevels (shapes) you have

n	# of sublevels	Which sublevels?
1	1	1s
2	2	2s 2p
3	3	3s 3p 3d
4	4	4s 4p 4d 4f

D. Practice Questions

Sublevel	Shape	#orbitals	# of e-
s	sphere	1	2
p	peanut	3	6
d	Double peanut	5	10
f	flower	7	14

n	#sublevels	which sublevels
1	1	1s
2	2	2s 2p
3	3	3s 3p 3d
4	4	4s 4p 4d 4f

1. How many electrons can go in the 3rd principle energy level? **2 + 6 + 10 = 18**
2. How many orbitals are there in the 3d? **5**

D. Practice Questions

Sublevel	Shape	#orbitals	# of e-
s	sphere	1	2
p	peanut	3	6
d	daisy	5	10
f	flower	7	14

n	#sublevels	which sublevels
1	1	1s
2	2	2s 2p
3	3	3s 3p 3d
4	4	4s 4p 4d 4f

3. How many orbitals are there in the 2nd principle energy level? **1 + 3 = 4**
4. How many electrons can go in the 3s sublevel? **2**

Sublevel	Shape	#orbitals	# of e-
s	sphere	1	2
p	peanut	3	6
d	daisy	5	10
f	flower	7	14

n	#sublevels	which sublevels
1	1	1s
2	2	2s 2p
3	3	3s 3p 3d
4	4	4s 4p 4d 4f

5. How many electrons can go in a single orbital? **2**
6. List the sublevels in the 4th principle quantum energy level? **4s, 4p, 4d, 4f**

Hog Hilton

You are the manager of a prestigious new hotel in downtown Lodi—the "Hog Hilton". It's just the "snort of the town" and you want to keep its reputation a cut above all the other hotels. Your problem is your clientele. They are hogs in the truest sense.

Your major task is to fill rooms in your hotel. The Hog Hilton only has stairs. You must fill up your hotel keeping the following rules in mind:

1) Hogs are lazy, they don't want to walk up stairs!

2) Hogs want to room by themselves, but they would rather room with another hog than walk up more stairs.

3) If hogs are in the same room they will face in opposite directions.

4) They stink, so you can't put more than two hogs in each room.

Hog Hilton

Your hotel looks like the diagram below:

6th floor _____ _____ _____ _____ _____

5th floor _____ _____ _____

4th floor _____

3rd floor _____ _____ _____

2nd floor _____

1st floor _____

$$\begin{array}{r} 9 \\ -\ 2 \\ \hline 7 \\ -\ 2 \\ \hline 5 \end{array}$$

Book 9 hogs into the rooms.

Hog Hilton

Your hotel looks like the diagram below:

6th floor _____ _____ _____ _____ _____
5th floor _____ _____ _____
4th floor _____ _____
3rd floor _____ _____ _____
2nd floor _____ _____
1st floor _____

15
- 2
13
- 2
11
- 6
5
- 2
3

Book 15 hogs into the rooms.

Hog Hilton

Your Turn: ⇧ = ↑ ⇩ = ↓

6th floor _____ _____ _____ _____ _____
5th floor _____ _____ _____
4th floor _____
3rd floor _____ _____ _____
2nd floor _____
1st floor _____

Now you will relate the "Hog Hilton" to electron orbitals. Electron orbitals are modeled by the picture on the left and are grouped into principal energy levels.

3d ___ ___ ___ ___ ___ n=3
4s ___ n=4
3p ___ ___ ___ n=3
3s ___ n=3
2p ___ ___ ___ n=2
2s ___ n=2
1s ___ n=1

6th floor ___ ___ ___ ___ ___
5th floor ___ ___ ___
4th floor ___
3rd floor ___ ___ ___
2nd floor ___
1st floor ___

4p ___ ___ ___
3d ___ ___ ___ ___ ___
4s ___
3p ___ ___ ___
3s ___
2p ↑ ↑ ↑
2s ↑↓
1s ↑↓

7 electrons
- 2
5
- 2
3

Sulfur
atomic number- 16

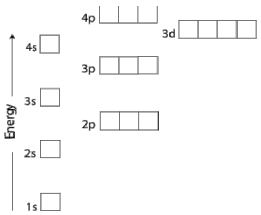
4p ___ ___ ___
3d ___ ___ ___ ___ ___
4s ___
3p ↑↓ ↑ ↑
3s ↑↓
2p ↑↓ ↑↓ ↑↓
2s ↑↓
1s ↑↓

16
- 2
14
- 2
12
- 6
6
- 2
4

Orbital Diagrams

How do you write electron configurations?

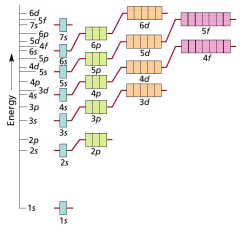
Electron Filling Order



1s
2s 2p
3s 3p 3d
4s 4p 4d 4f
5s 5p 5d 5f …
6s 6p 6d … … …

B. Rules

- **1. Aufbau (Build up) Principle**
  - Electrons fill the lowest energy orbitals first.



Hog Hilton:

Hogs are Lazy!

B. Rules

- **2. Pauli Exclusion Principle**
  - Each orbital can hold TWO electrons with opposite spins. Draw up arrow first!

Hog Hilton:

They stink! And They must face opposite directions.

B. Rules

- **3. Hund's Rule**
  - Within a sublevel, place one e^- per orbital before pairing them.

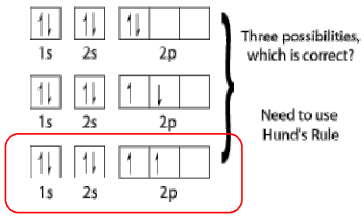
WRONG

RIGHT

B. Rules

- **3. Hund's Rule**
  - Within a sublevel, place one e^- per orbital before pairing them.

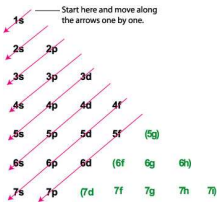
Hog Hilton: Hogs can't stand each other



III. Ground State Electron Configuration

Ground State

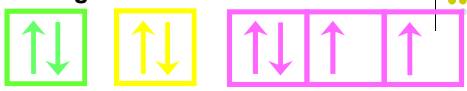
- Ground state: lowest possible energy state. Fills up electrons according to the rules.



A. Electron Configuration from orbital diagram

- **Orbital Diagram**

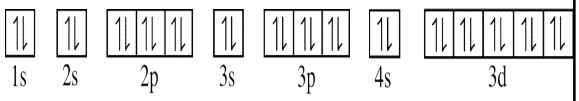
O



8e⁻ 1s 2s 2p

Ground State Electron Configuration

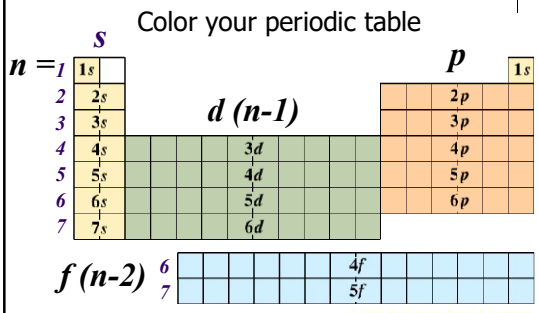
$1s^2\ 2s^2\ 2p^4$



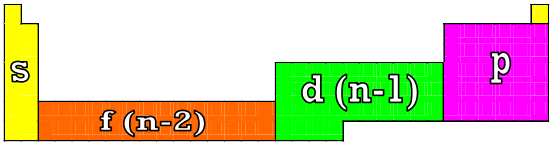
$1s^2\ 2s^2\ 2p^6 3s^2\ 3p^6 4s^2 3d^{10}$

B. Electron config from P-table

Color your periodic table



B. Electron config from P-table



Meaning:

$1s^1$

1 electron in that sublevel

Energy level (n) = 1

s-sublevel

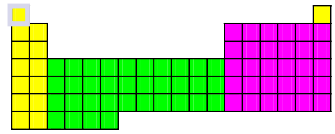
On Periodic Table:

$1s^1$

1st column of s-block

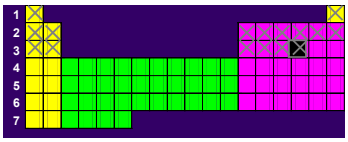
1st Period (Row #)

s-block



B. Periodic Patterns

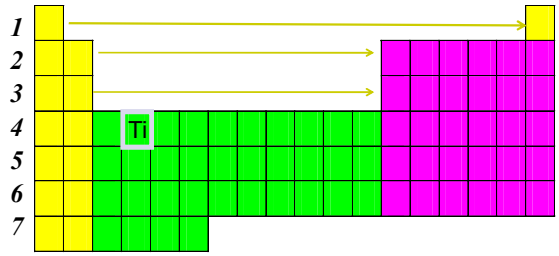
- **Example: S**



$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

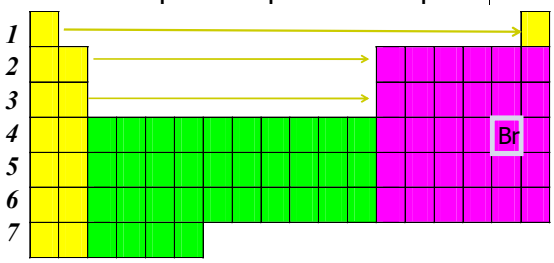
What is the electron configuration for Titanium (Ti)?

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$



What is the electron configuration for Br?

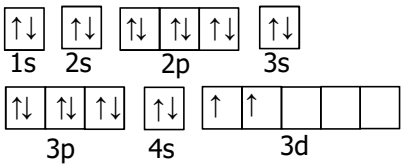
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}4p^5$



Using electron configuration to draw orbital diagrams

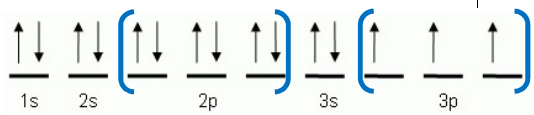
Shape	# orbitals
s	1
p	3
d	5
f	7

Ti: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$



Write in Your notebook at the bottom

If you insist…

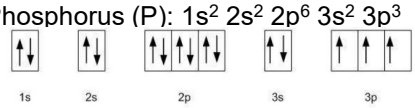


Electron Configuration Practice

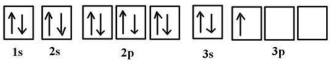
1. Electron configuration & orbital diagram
   A. Phosphorus (P)
   B. Aluminum (Al)

Electron Configuration Practice

A. Phosphorus (P): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$



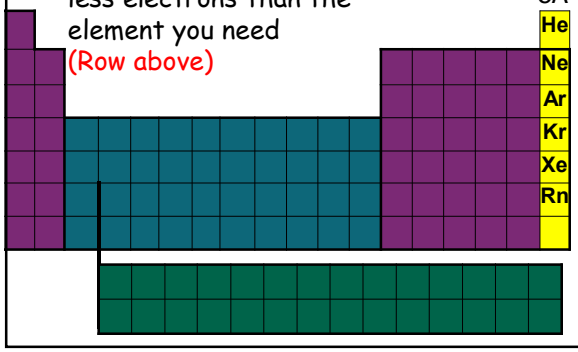
B. Aluminum (Al): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$



D. Noble Gas Notation

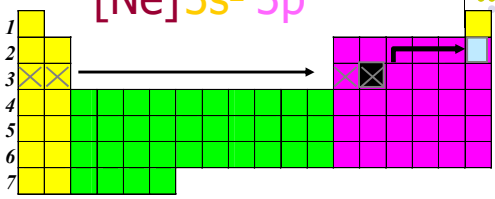
*Use a Noble gas with less electrons than the element you need (Row above)

Noble Gases → 8A



Noble Gas Shorthand **Ex –** Silicon

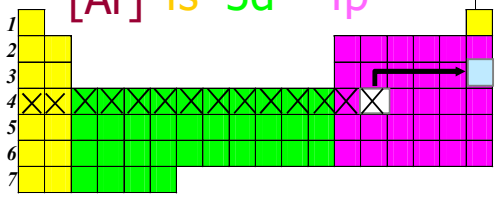
[Ne] $3s^2\ 3p^2$



Noble Gas Shorthand

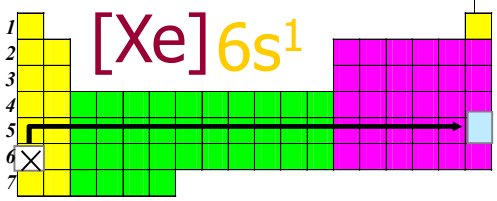
- **Ex** - Germanium

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



Noble Gas Shorthand

- **Ex** - Cesium



Electron Configuration Practice

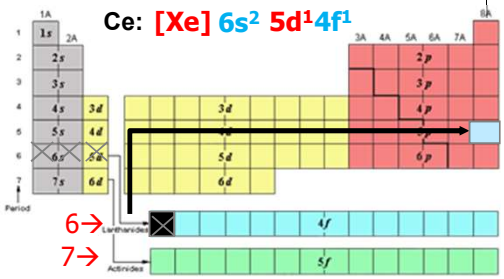
2. Noble Gas Notation
   a) Zirconium (Zr)
   b) Selenium (Se)
   c) Lanthanum (La)

Electron Configuration Practice

2. Noble Gas Notation
   a) Zirconium (Zr): [Kr] $5s^2$ $4d^2$
   b) Selenium (Se): [Ar] $4s^2$ $3d^{10}$ $4p^4$
   c) Lanthanum (La): [Xe] $6s^2$ $5d^1$

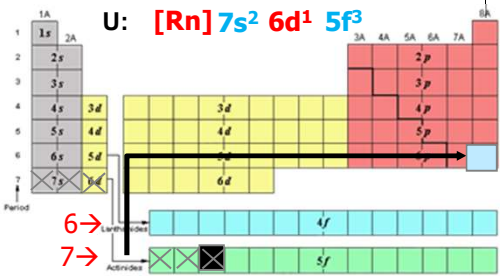
E. Going through the F-block

Ce: [Xe] $6s^2$ $5d^1$ $4f^1$



E. Going through the F-block

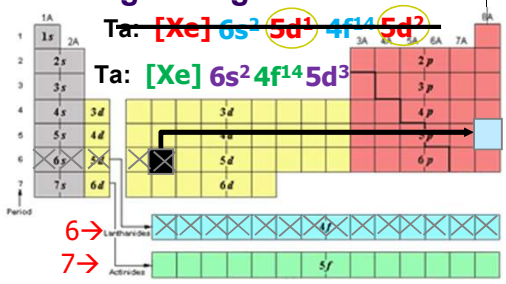
U: [Rn] $7s^2$ $6d^1$ $5f^3$



E. Going through the F-block

~~Ta: [Xe] $6s^2$ $5d^1$ $4f^{14}$ $5d^2$~~

Ta: [Xe] $6s^2$ $4f^{14}$ $5d^3$

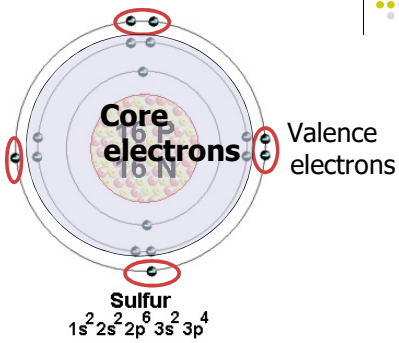


Electron Configuration Practice

D. Neptunium (Np)
E. Osmium (Os)

Electron Configuration Practice

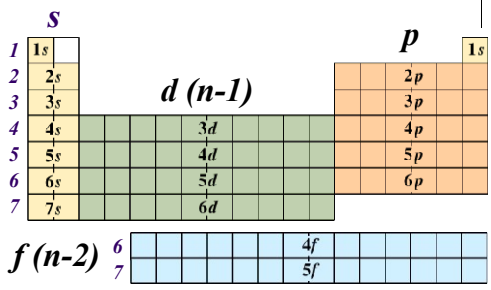
D. Neptunium (Np): [Rn] $7s^2\ 6d^1\ 5f^4$
E. Osmium (Os): [Xe] $6s^2\ 4f^{14}\ 5d^6$



F. Electron Dot Structures

- Show # valence electrons (e- in outermost/highest energy level)

No element has more than 8 valence electrons (only use s and p orbitals)



F. Electron Dot Structures

- Show # valence electrons (e- in outermost/highest energy level)
- Ex: Sulfur = **[Ne] 3s② 3p④**
- It has 6 valence electrons

F. Electron Dot Structures

- Ex: Zr=
- **[Kr] 5s^2 4d^2**

Zr

Group Work

Write the noble gas notation shortcut and the Lewis dot diagram for every atom in the following groups

Table	Group
1	1A
2	2A
3	3A
4	4A

Table	Group
5	5A
6	6A
7	7A
8	8A

e- configuration practice 2

Element	E-config (Longhand)	Noble gas (shorthand)		
N		Skip 3 lines		
Se		↓		
Sr		Skip 4 lines		
		↓		

e- configuration practice 2

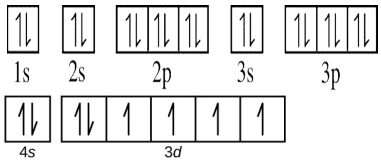
Element	E-config (Longhand)	Noble gas (shorthand)		
N		Skip 3 lines		
Se		↓		
Sr		Skip 4 lines		
Nd		↓		
Pu	xxxxxxxx			
Re	xxxxxxxx			

e- configuration practice 2

Element	E-config (Longhand)	Noble gas (shorthand)	# valence e-	Dot structure
N		Skip 3 lines		
Se		↓		
Sr		Skip 4 lines		
Nd		↓		
Pu				
Re				

e- configuration practice 1

Element	e- configuration	orbital Diagram
H		
He		
Be		
F		
S		
Cl		
Mg		
Si		

Electron Configuration Practice

A. Iron (Fe): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$