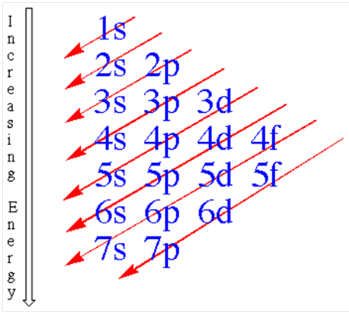
7.10 - 7.11 - Periodic Table History & Electron Configuration

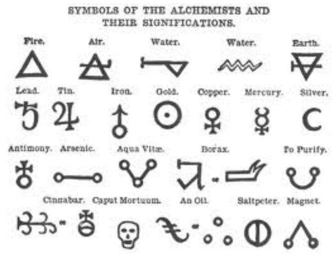


Alchemists

Medieval chemists tried turning base metals (Fe, Pb) to gold.

They also tried making an 'elixir of life' bestowing immortality upon the consumer.

Several symbols they used for their ingredients:



Development

The periodic table is the result of many contributions.

Antoine Lavoisier made an organized list of all 33 elements known in the late 1700's.

Later, more elements were discovered by electrolysis (electrical separation).

Antoine Lavoisier

Johann Dobereiner & John Newlands

Johann Dobereiner (1780 - 1849) found several groups of three elements (called *triads*) with similar properties. Example: chlorine, bromine, and iodine.

John Newlands organized elements by atomic mass (1866), and noted what became known as the 'Law of Octaves' (like music) – wherein every 8th element had similar properties.

This grouping did not manage to explain enough elements to be widely accepted.

John Newlands

Newlands' Octaves (his 'Periodic Table' of 1866)

H	Li	Ga	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co, Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce, La	Zr	Di, Mo	Ro, Ru
Pd	Ag	Cd	U	Sn	Sb	Te
I	Cs	Ba, V	Ta	W	Nb	Au
Pt, Ir	Tl	Pb	Th	Hg	Bi	Th

Lothar Meyer & Dmitry Mendeleev

Both demonstrated connection between properties and atomic mass.

Mendeleev published first → got credit.

Left blank spaces between elements where undiscovered elements could go.

vs.

Meyer Mendeleev

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

основанной на ихъ атомномъ вѣсѣ и химическомъ сходствѣ.

Ti = 50 Zr = 90 ? = 180.
V = 51 Nb = 94 Ta = 182.
Cr = 52 Mo = 96 W = 186.
Mn = 55 Rh = 104,4 Pt = 197,4
Fe = 56 Rn = 104,4 Ir = 198.
Ni = Co = 59 Pl = 106,6 O- = 199.
H = 1 Cu = 63,4 Ag = 108 Hg = 200.
Be = 9,4 Mg = 24 Zn = 65,2 Cd = 112
B = 11 Al = 27,4 ? = 68 Ur = 116 Au = 197?
C = 12 Si = 28 ? = 70 Sn = 118
N = 14 P = 31 As = 75 Sb = 122 Bi = 210?
O = 16 S = 32 Se = 79,4 Te = 128?
F = 19 Cl = 35,5 Br = 80 I = 127
Li = 7 Na = 23 K = 39 Rb = 85,4 Cs = 133 Tl = 204.
Ca = 40 Sr = 87,6 Ba = 137 Pb = 207.
? = 45 Ce = 92
?Er = 56 La = 94
?Yt = 60 Di = 95
?In = 75,6 Th = 118?

Д. Менделѣевъ

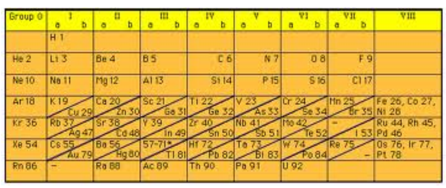
Henry Moseley

Realized ordering by atomic mass led to errors in properties. Ex: Ar & K switched.

He determined that each element has a unique number of protons (1913).

Arranged elements by atomic number → clear periodic trends emerged.

Henry Moseley



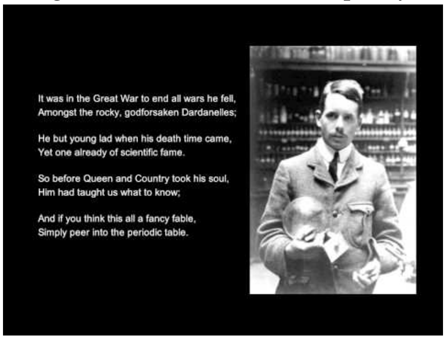
Group 0	I a / b	II a / b	III a / b	IV a / b	V a / b	VI a / b	VII a / b	VIII
	H 1							
He 2	Li 3	Be 4	B 5	C 6	N 7	O 8	F 9	
Ne 10	Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17	
Ar 18	K 19 / Cu 29	Ca 20 / Zn 30	Sc 21 / Ga 31	Ti 22 / Ge 32	V 23 / As 33	Cr 24 / Se 34	Mn 25 / Br 35	Fe 26, Co 27, Ni 28
Kr 36	Rb 37 / Ag 47	Sr 38 / Cd 48	Y 39 / In 49	Zr 40 / Sn 50	Nb 41 / Sb 51	Mo 42 / Te 52	– / I 53	Ru 44, Rh 45, Pd 46
Xe 54	Cs 55 / Au 79	Ba 56 / Hg 80	57-71* / Tl 81	Hf 72 / Pb 82	Ta 73 / Bi 83	W 74 / Po 84	Re 75 / –	Os 76, Ir 77, Pt 78
Rn 86	–	Ra 88	Ac 89	Th 90	Pa 91	U 92		

Henry Moseley

Moseley died in the campaign of Gallipoli during WWI.

His death prompted the British government to forbid prominent scientists from enlisting in front-line positions. Other governments followed this policy.

He was 27.



Quick Review

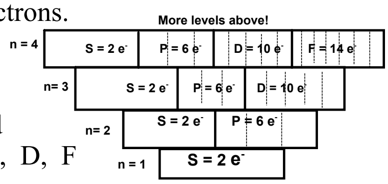
The system for housing ground-state electrons in an atom is like a weird, seven floor apartment building; each floor has a certain number of apartments, those apartments have a certain number of rooms, and each room holds two electrons.

Energy Levels (n): 1 - 7

4 differently shaped sub-levels (l): S, P, D, F

Orbitals (m_l): S = 1, P = 3, D = 5, F = 7

Electrons (m_s): 2/orbital



Electron Apartment Complex

Electron Configuration Guiding Principles

Electron ordering system governed by 3 principles:

- Aufbau
- Pauli Exclusion
- Hund's Rule

1 - Aufbau Principle

Means "arrange" in German.(German Language Demo).

Barbara Aufbau Chris Aufbau Heike Aufbau

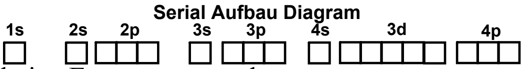
Electrons occupy the lowest energy orbitals available, and as protons are added one-by-one on the periodic table, electrons enter the various electron levels sequentially.

Orbital (Aufbau) Diagrams

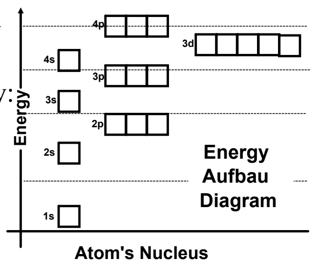
Orbital Diagrams portray electrons as they enter their orbitals, often shown as a series of boxes or lines with corresponding energy levels denoted.

Serial portrayal: simply the Aufbau sequence (to be shown later):

Serial Aufbau Diagram



Relative Energy portrayal: shows comparative energy of different levels as electrons file in sequentially:



Energy Aufbau Diagram

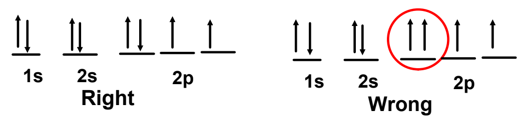
2 - Pauli Exclusion Principle

Electrons have a quantum "spin": up ↑ or down ↓.

Arrows represent electrons, and they share an orbital only if they are opposite.

This prevents two electrons from having the same set of four quantum numbers.

Example: Oxygen has 8 electrons:



3 - Hund's Rule

Known as "The Bus Rule". Imagine getting on a bus in a strange town, where would you sit?

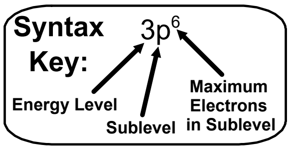
Electrons share orbitals if no unoccupied orbitals remain - minimizing interactions with other electrons and reducing electrical potential energy.

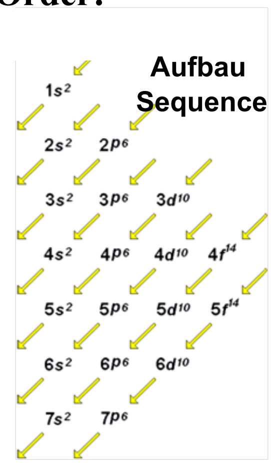
Orbital Diagrams

			1s	2s	2p
Boron,	B	5 Electrons	↑↓	↑↓	↑ _ _
Carbon,	C	6 Electrons	↑↓	↑↓	↑ ↑ _
Nitrogen,	N	7 Electrons	↑↓	↑↓	↑ ↑ ↑
Oxygen,	O	8 Electrons	↑↓	↑↓	↑↓ ↑ ↑

Full Electron Configuration - Aufbau Order:

Procedure:
1. Determine your element's number of electrons.
2. Use the order to assign electrons until you run out, following the sequence of arrows. When you get to the end of a diagonal series, loop back to the top of the next diagonal.

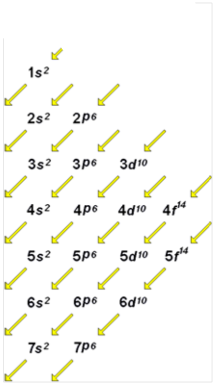




Configuration Examples
1. Sodium

Electrons? = 11
First two go in 1s,
second two: 2s,
next six: 2p,
last one goes in 3s.

Answer: $1s^2 2s^2 2p^6 3s^1$



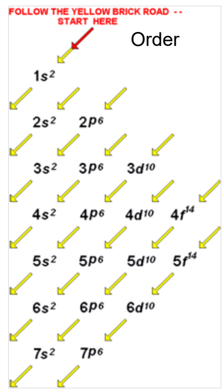
2. Zinc Example

Write the full configuration for:

Zinc

Zinc = 30 Electrons

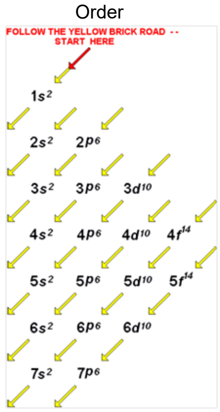
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$



3. Boron Example

Write the full configuration for:

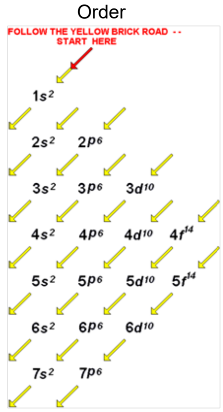
Boron
5 electrons
$1s^2 2s^2 2p^1$



4. Chlorine Example

Write the full configuration for:

Chlorine
17 electrons
$1s^2 2s^2 2p^6 3s^2 3p^5$



5. Tin Example

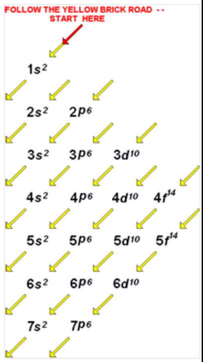
Write the complete electron configuration for:

Tin (Sn)

Electrons = 50

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

This is tedious business!



Noble Gas Notation

To save time, the Noble Gas Notation shortcut is used.

A. Determine electrons. Ex: Tin = 50 e^-.

B. Bracket previous noble gas's symbol; subtract its electrons from your element's. Ex: [Kr]

C. **Resume counting from s sublevel of your element's row. Ex: 5s**

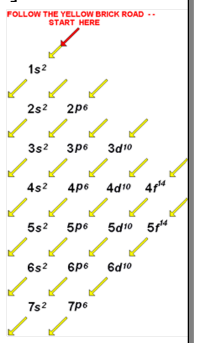
Tin becomes: [Kr] $5s^2 4d^{10} 5p^2$

6. Platinum Example (Pt = 78 e^-)

Previous noble gas = Xe; = 54e^-.

Resume at 6s with remaining 24e^-:

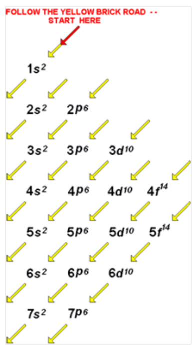
Pt = [Xe] $6s^2 4f^{14} 5d^8$



7. Polonium Example

Write the noble gas electron configuration for Polonium (Po)

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



Exceptions

The Aufbau order works up to Vanadium; but half- or totally-filled d-sublevels are more stable: electrons move from s sublevels if that will yield a half or totally full d (or f sometimes) sublevel.

Cr, Mo, W; and Cu, Ag, Au are exceptions: memorize them!

Cr = [Ar]$4s^1 3d^5$ NOT: [Ar]$4s^2 3d^4$

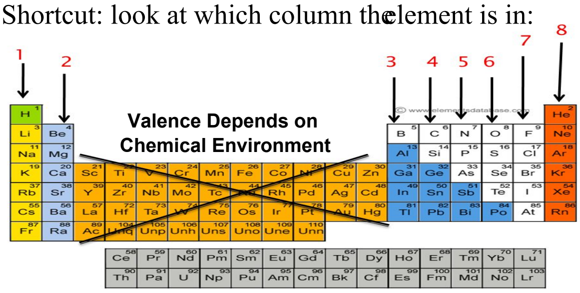
Cu = [Ar]$4s^1 3d^{10}$ NOT: [Ar]$4s^2 3d^9$

Valence Electrons

Def: Electrons in outermost energy level which determine chemical properties.

Ex: Sulfur = [Ne]$3s^2 3p^4$ = 6 valence electrons

Shortcut: look at which column the element is in:



8. Valence Example

How many valence electrons do these elements have?

S

B

Ca

Sb

Sn

N

8. Valence Answer

S = 6

B = 3

Ca = 2

Sb = 5

Sn = 4

N = 5

Quantum Numbers Structure

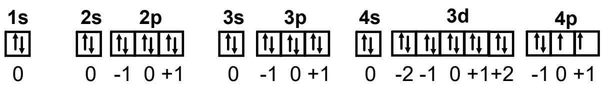
Given a principal quantum number *n*, with angular momentum numbers (sublevels) (l) in integer values from 0 to *n* - 1, magnetic quantum numbers (orbitals) (m_l) ranging from $-l$ *to* $+l$, and a spin (m_s) of +/- ½, here's how it shakes out:

n	*l*	Sublevels	m_l	Orbitals
1	0	1s	0	1
2	0 1	2s 2p	0 -1, 0, +1	1 3
3	0 1 2	3s 3p 3d	0 -1, 0, +1 -2, -1, 0, +1, +2	1 3 5
4	0 1 2 3	4s 4p 4d 4f	0 -1, 0, +1 -2, -1, 0, +1, +2 -3, -2, -1, 0, +1, +2, +3	1 3 5 7

Merging Quantum Numbers & Orbital Diagrams

The last component of quantum number structure links quantum numbers to orbital diagrams.

Using the Aufbau sequence, the last valence electron for the element selenium is shown, with quantum numbers of 4, 1, -1, -½:



9. Quantum Number Examples

A. Which element's last valence electron has quantum numbers of 3, 1, +1, +½?

Phosphorus.

B. What is the quantum number set for the last electron for the element silver?

5, 2, +2, -½.

Homework

Preview 12.3

12.1-.2 Problems in your Booklet
Due: Next Class

Attachments

Barbara Aufbau.MOV

Chris Aufbau.MOV

Heike Aufbau.MOV