

H																He	
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

H																He	
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	S

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	s
	p

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	s
	p
	d

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	s
	p
	d
	f

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	s
	p
	d (n-1)
	f (n-2)

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Electron Configurations (2.3.4 & 12.1.6)

- It is helpful to know how the electrons are arranged within an atom.
 - This explains and predicts much of the chemistry involved, such as reactions that will occur and ions that will be formed.
- Energy levels –
 - Horizontal rows correspond to energy levels
 - 1-7

- **Energy Sublevels (s,p,d,f) (12.1.3)**
 - Within each energy level are sublevels (12.1.4)
 - Energy level 1 has s only.
 - Energy level 2 has s and p.
 - Energy level 3 has s, p, and d.
 - Energy levels 4 and above have s, p, d, and f.
- **Orbitals – contain up to 2 electrons each.**
 - s sublevels have 1 orbital
 - p sublevels have 3 orbitals
 - d sublevels have 5 orbitals
 - f sublevels have 7 orbitals

Writing Electron Configurations

Examples –write electron configurations:

- 1 O
- 2 Al
- 3 Cl
- 4 Ni
- 5 Fe^{2+}
- 6 F^-

Orbital Filling Diagrams

- This is a visual representation of an electron configuration:
 - Each orbital is represented by a box (\square)
 - Each electron is represented by an arrow (\uparrow or \downarrow)
 - All orbitals in the same sublevel are drawn together (ex. 3p $\square\square\square$)

Hund's Rule

- An electron configuration tells us in which orbitals the electrons for an element are located.
- Three rules:
 - electrons fill orbitals starting with lowest n and moving upwards;
 - no two electrons can fill one orbital with the same spin (**Pauli Exclusion Principle**);
 - for degenerate orbitals, electrons fill each orbital singly before any orbital gets a second electron (**Hund's rule**).

Examples

Draw orbital filling diagrams:

1 O

2 Al

3 Cl

4 Ni

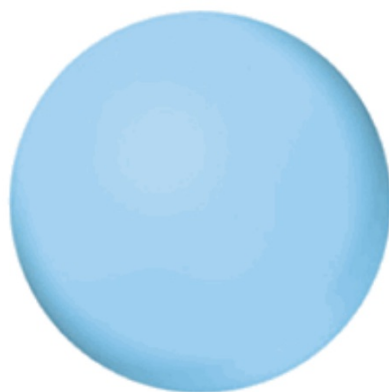
Representations of Orbitals

(12.1.5)

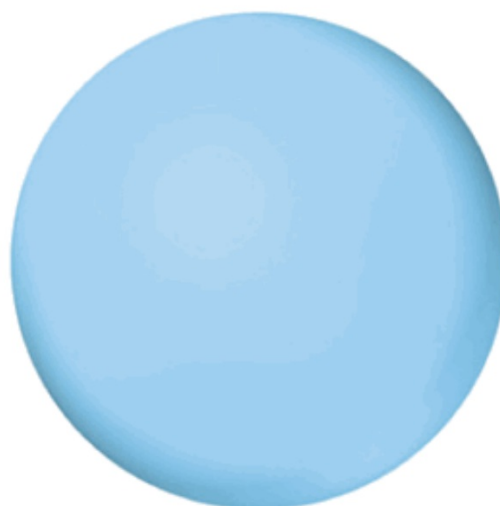
The s-Orbitals



1s



2s

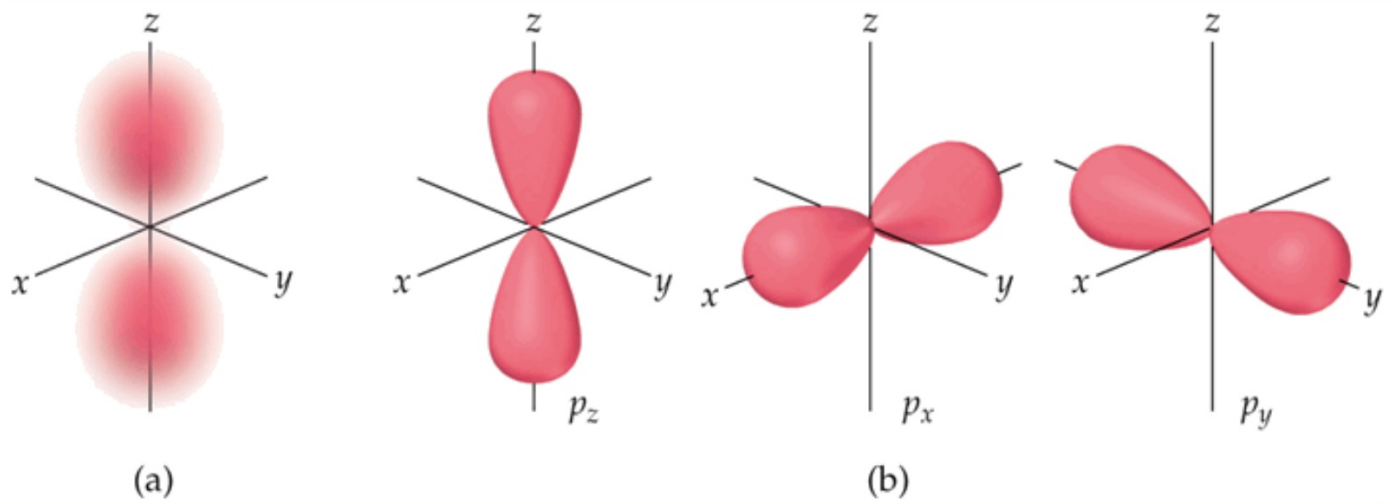


3s

The p-Orbitals

- There are three p -orbitals p_x , p_y , and p_z .
- The three p -orbitals lie along the x -, y - and z - axes of a Cartesian system.
- The letters correspond to allowed values of m_l of -1, 0, and +1.
- The orbitals are dumbbell shaped.
- As n increases, the p -orbitals get larger.
- All p -orbitals have a node at the nucleus.

The p-Orbitals



Ionization Energy

- The first ionization energy, I_1 , is the amount of energy required to remove an electron from a gaseous atom:



- The second ionization energy, I_2 , is the energy required to remove an electron from a (+1) gaseous ion:



- The larger ionization energy, the more difficult it is to remove the electron.

Variations in Successive Ionization Energies (12.1.1 & 12.1.2)

TABLE 7.2 Successive Values of Ionization Energies, I , for the Elements Sodium through Argon (kJ/mol)

Element	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Na	496	4560					
Mg	738	1450	7730				
Al	578	1820	2750	11,600			
Si	786	1580	3230	4360	16,100		
P	1012	1900	2910	4960	6270	22,200	
S	1000	2250	3360	4560	7010	8500	27,100
Cl	1251	2300	3820	5160	6540	9460	11,000
Ar	1521	2670	3930	5770	7240	8780	12,000

- Notice that I_1 values show the existence of energy levels and sublevels.
- Notice where ionization energy “jumps” for each individual element. How is this related to electron configuration?