

## § 6-4 Atomic Orbitals, Shapes and Sizes

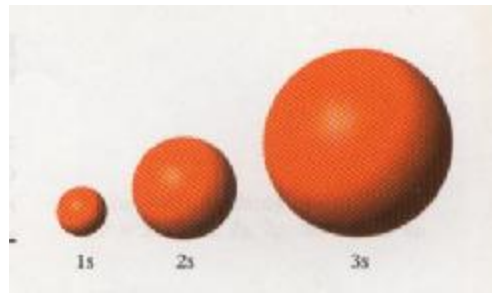


Fig. 6.6: s orbits.

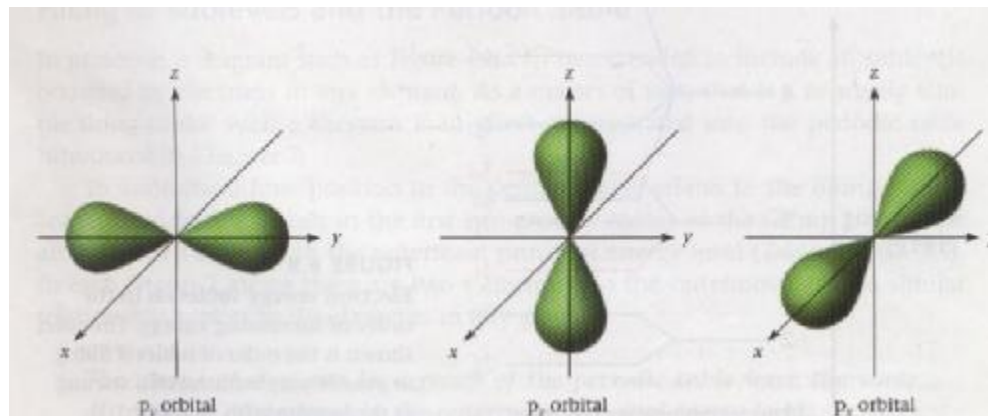
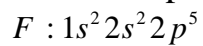


Fig. 6.7: p orbits. ( $p_x, p_y, p_z$  orbit)

## § 6-5 Electron configurations in atoms 原子之電子組態

The simplest way to describe the management of electrons in an atom.



## § Electron configuration from sublevel energies

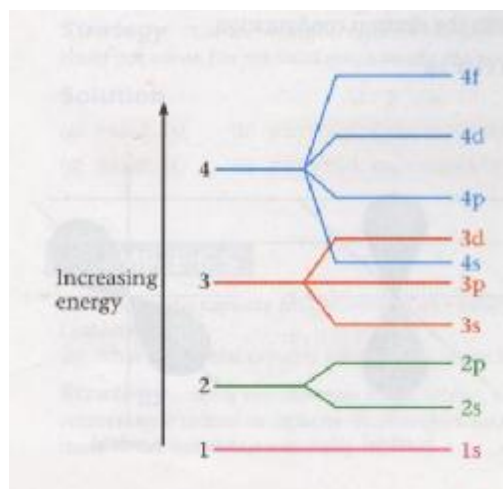
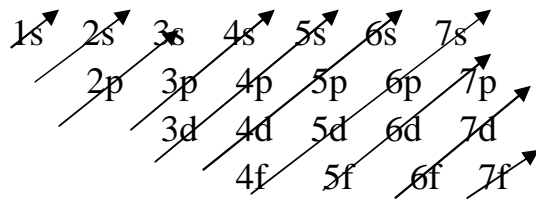
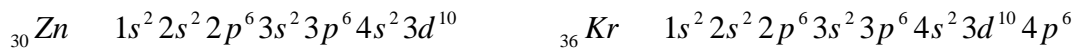
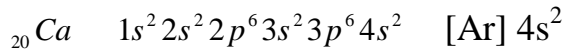
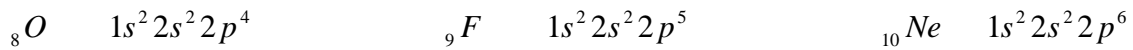
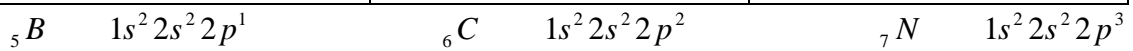


Fig 6.8: Electron energy sublevels in the order of increasing energy.



第一週期	$1s^2$	2
第二週期	$2s^2 2p^6$	8
第三週期	$3s^2 3p^6$	8
第四週期	$4s^2 3d^{10} 4p^6$	18
第五週期	$5s^2 4d^{10} 5p^6$	18
第六週期	$6s^2 4f^{14} 5d^{10} 6p^6$	32
第七週期	$7s^2 5f^{14} 6d^{10} 7p^6$	32



Ex 6-6 : Find the electron configurations of the sulfur and iron atoms.



## § Abbreviated electron configuration

前一週期之鈍氣 + 最後一週期之電子組態

	Electron configuration	Abbreviated electron configuration
${}_{16}S$	$1s^2 2s^2 2p^6 3s^2 3p^4$	$[Ne] 3s^2 3p^4$
${}_{28}Ni$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$	$[Ar] 4s^2 3d^8$

## § Filling of sublevels and the periodic table

週期表與電子組態是相對照的

1. Group 1, 2  $\Rightarrow$  填入 s orbital

IA, IIA

2. Group 13 ~ 18  $\Rightarrow$  填入 p orbital

IIIA ~ VIIIA

3. transition metal Group 3 ~ 12  $\Rightarrow$  填 d orbital
4. inner transitional element  $\Rightarrow$  填 f orbital

Half-life 半衰期  $t_{1/2}$  :

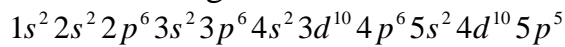
The time for a radioactive element to reduce its weight to half. 一放射性元素，其重量減為原先一半所需之時間。  $t_{1/2} \uparrow \Rightarrow$  安定性  $\uparrow$

## § Electron configuration from the periodic table

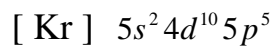
Ex 6-7: For the iodine atom, write

Ans:  ${}_{53}I: {}_9F; {}_{17}Cl; {}_{35}Br; {}_{53}I \quad 53 - 2 - 8 - 8 - 18 = 17$

a) electron configuration



b) abbreviated electron configuration



	Predicted		observed	
${}_{24}Cr$	$[Ar] 4s^2 3d^4$		$[Ar] 4s^1 3d^5$	
				$\Rightarrow$ 可提高穩定性
${}_{29}Cu$	$[Ar] 4s^2 3d^9$		$[Ar] 4s^1 3d^{10}$	

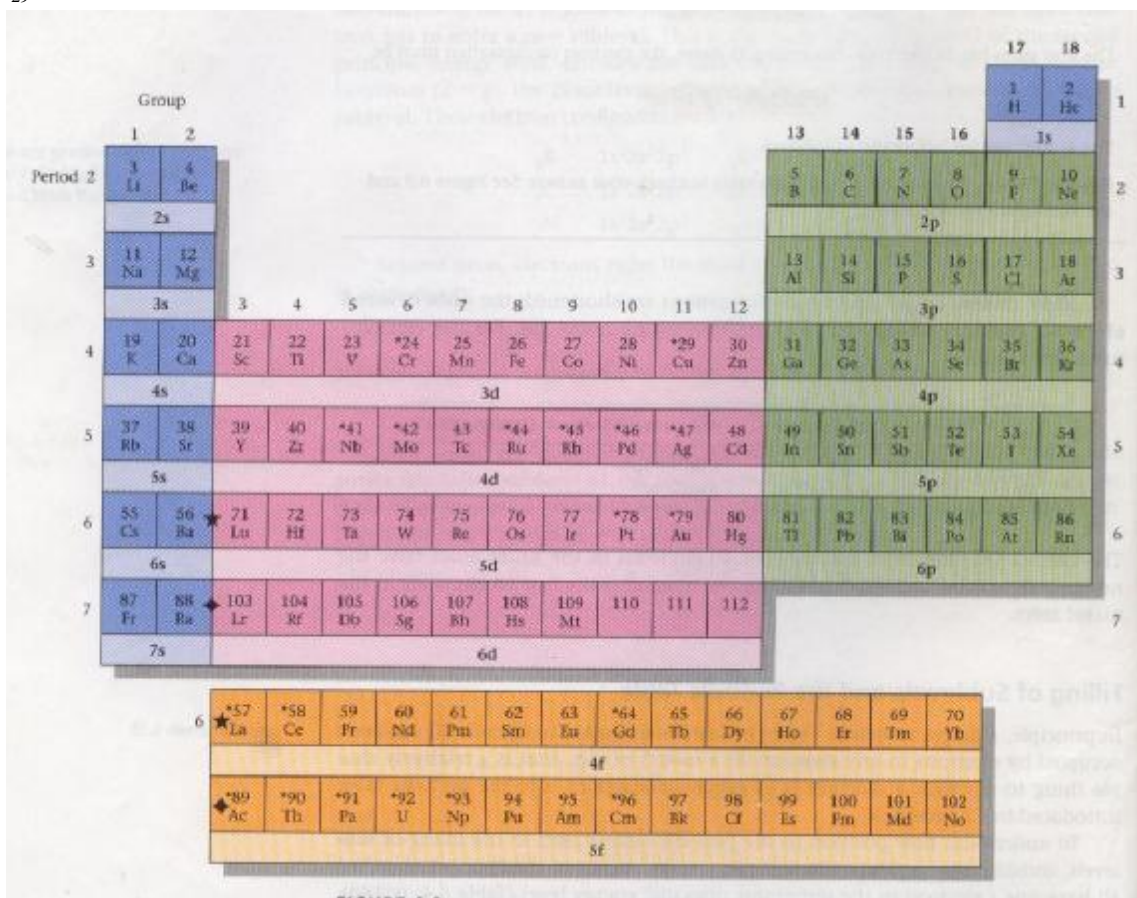


Fig 6-9: 圖中標 \* 者 predicted 與 observed 些微不同

## §6-6 Orbital diagrams of atoms 原子軌域圖

Show how electrons are distributed among orbitals; orbital 用 ( ) 表示  
電子以↑or↓表示

↳ 依 spin 方向而異

	1s	2s	2p			
${}_5B$	(↑↓)	(↑↓)	(↑ )	( )	( )	
	1s	2s	2p			
${}_6C$	(↑↓)	(↑↓)	(↑ )	(↑ )	( )	最安定

**Hund's law :**

When several orbitals of equal energy are available, as in a given sublevel, electrons enter singly with parallel spins.

- in all filled orbitals, the two electrons have opposed spins.
- in accordance with Hund's rule, within a given sublevel there are as many half-filled orbitals as possible.  
副軌域先各排一個，才排入第二個電子

	1s	2s	2p			
${}_7N$	(↑↓)	(↑↓)	(↑ )	(↑ )	(↑ )	
${}_8O$	(↑↓)	(↑↓)	(↑↓)	(↑ )	(↑ )	
${}_9F$	(↑↓)	(↑↓)	(↑↓)	(↑↓)	(↑ )	
${}_{10}Ne$	(↑↓)	(↑↓)	(↑↓)	(↑↓)	(↑↓)	

**paramagnetic 順磁性的 :** A solid has **unpaired electrons** present, it will be attracted by the magnetic field.

**diamagnetic 逆磁性的 :** A solid contains only paired electrons, it is slightly repelled by the magnetic field.

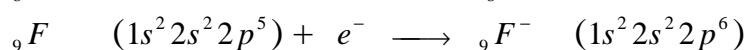
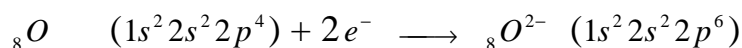
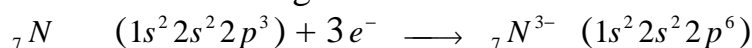
Ex 6-8: Construct orbital diagrams for atoms of sulfur and iron.

Ans:      1s   2s   2p                      3s   3p  
 ${}_{16}S$       (↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑ ) (↑ )

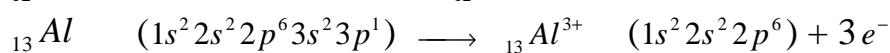
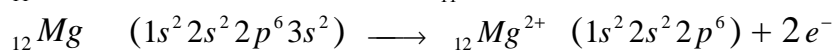
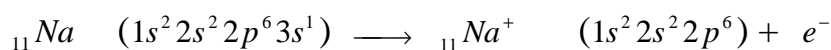
                 1s   2s   2p                      3s   3p  
 ${}_{26}Fe$       (↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)(↑↓)  
                  4s   3d  
                  (↑↓)(↑↓)(↑ ) (↑ ) (↑ ) (↑ )

## § 6-7 Electron arrangements in monatomic ions

Ions with Noble-gas structure



**b** 相同電子組態



$N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+}, Al^{3+} \Rightarrow$  等電子 **isoelectronic**

They have same electron configuration.

Group 1 +1 (IA)

Group 16 -2 (VIA)

Group 2 +2 (IIA)

Group 17 -1 (VIIA)

MX M : Li, Na, K, Rb, Cs, Fr

X : F, Cl, Br, I, At

MX<sub>2</sub> M : Be, Mg, Ca, Sr, Ba, Ra

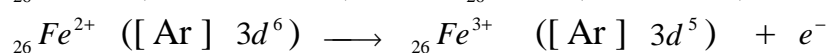
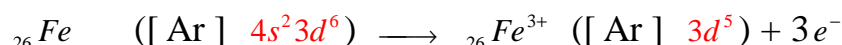
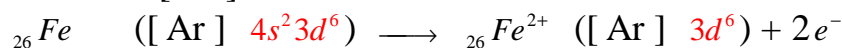
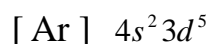
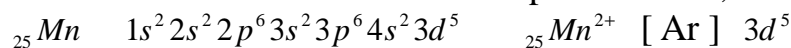
X : F, Cl, Br, I, At

MO M : Be, Mg, Ca, Sr, Ba, Ra

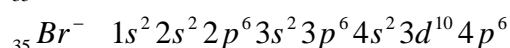
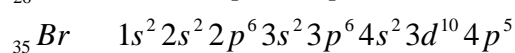
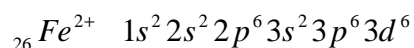
X : O

Transition metal cations:

When transition metal atoms form positive ions, **the outer s electrons are lost first.**



**Ex 6-9 :**    a)  $Fe^{2+}$     b)  $Br^-$  之 electron configuration



## § 6-8 Periodic trends in the properties of atoms.

The chemical and physical properties of elements are a **periodic function of atomic number.**

討論：

Atomic radius  
 Ionic radius                      horizontally or vertically in the periodic table  
 Ionization energy  
 Electronegativity

§ Atomic radius :

One half the distance of closest approach between atoms in an elemental substance.

Radius : 半徑

- decrease across a period from left to right in the periodic table  
 同一週期  $Z \uparrow \Rightarrow r \downarrow$
- increase down a group in the periodic table  
 同一族  $Z \uparrow \Rightarrow r \uparrow$

§ Ionic radius :

Increases moving down a group in the periodic table

同一族  $Z \uparrow \Rightarrow$  ionic  $r \uparrow$

Radii of both cations (left) and anions (right) decrease from left to right across a period.

同一週期  $Z \uparrow \Rightarrow r \downarrow$                        $Li^+ > Be^{2+}$                        $O^{2-} > F^-$

- positive ions : radius < atom radius  
 (cations)                       $Na^+ < Na$   
 $r = 0.095nm$        $r = 0.186nm$
- negative ions : radius > atom radius  
 (anions)                       $Cl^- > Cl$   
 $r = 0.181nm$        $r = 0.099nm$

Ex 6-10 : Using only the periodic table, arrange each of the following sets of atoms and ions in order of increasing size.

- Ans : a)  ${}_{12}Mg, {}_{13}Al, {}_{20}Ca$                        $Al < Mg < Ca$
- b)  ${}_{16}S, {}_{17}Cl, {}_{16}S^{2-}$                        $Cl < S < S^{2-}$                       陰離子  $r^- > r$
- c)  ${}_{26}Fe, {}_{26}Fe^{2+}, {}_{26}Fe^{3+}$                        $Fe^{3+} < Fe^{2+} < Fe$                       陽離子  $r > r^+$

§ Ionization energy : 游離能

is a measure of how difficult it is to remove an electron from a gaseous atom.

一定 “+“ ←



ionization energy :

- increase across the periodic table from left to right.

同一週期  $Z \uparrow \Rightarrow \Delta E_1 \uparrow$  結論與 radius 相反  
例外 Be, B; Mg, Al

- decrease moving down the periodic table

同一族  $Z \uparrow \Rightarrow \Delta E_1 \downarrow$

Ex 6-11: Consider the three elements  ${}_6\text{C}$ ,  ${}_7\text{N}$ ,  ${}_{14}\text{Si}$ . Using only the periodic table, Predict which of the three elements has

- the largest and the smallest atomic radius
- the largest ionization energy and the smallest ionization energy

Ans :

- Radius :

${}_{14}\text{Si}$  最大  ${}_7\text{N}$  最小

- $\Delta E$  :

${}_7\text{N}$  最大  ${}_{14}\text{Si}$  最小

## § Electronegativity 負電性

Measures the ability of an atom to attract the electron to itself to form a covalent bond.

F 4.0 最活潑非金屬

Fr (Cs 0.8) 最活潑金屬

背 H(2.2); B(2.0); C(2.5); N(3.0); O(3.5); F(4.0); Si(1.9); P(2.2); S(2.6); Cl(3.2); Br(3.0); I(2.7) 之負電性值.