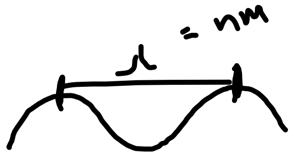
Ch 7:

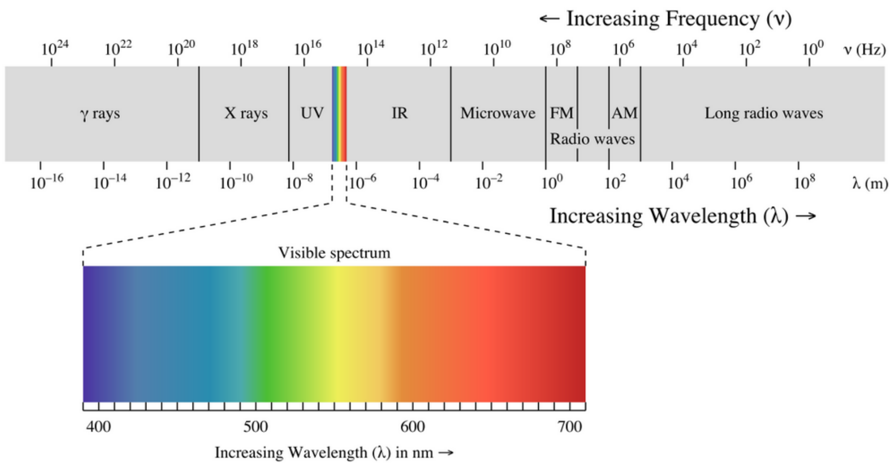
Electromagnetic radiation - all energy of wavelike behavior

λ = wavelength (meters)



ν = frequency (cycle/sec, sec^{-1}, Hz)

m $\lambda\nu$ = c (c = 3.00 x 10^8 m/s)



Practice with energy and wavelength equations:

Ex: The blue color in fireworks is from CuCl being heated to 1200 C. Light at a wavelength of 450 nm is then emitted. What increment of energy (the quantum) is emitted at this wavelength?

Photoelectric effect:

Energy is a stream of particles called photons

1) No electrons are emitted if minimum threshold energy is not enough ($V_{light} < V_0$)

http://www.youtube.com/watch?v=kcSYV8bJox8

2) If enough energy, e- will be emitted ($V_{light} > V_0$)

$E = h\nu$

Planck's 6.626×10^{-34} J·s/photon

e- packet of energy

* $E = h\nu$
* $c = \lambda\nu$

$\boxed{* \; E = \frac{hc}{\lambda}}$

Math with Einstein's work and photoelectric equation:

$E = mc^2$ ----> $m = E/c^2$

$m = \frac{h}{\lambda v}$ ----> $\lambda = \frac{h}{mv}$

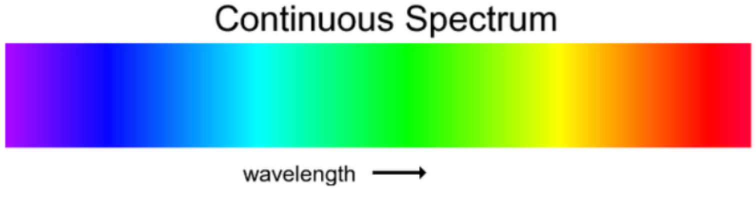
v = velocity m = mass

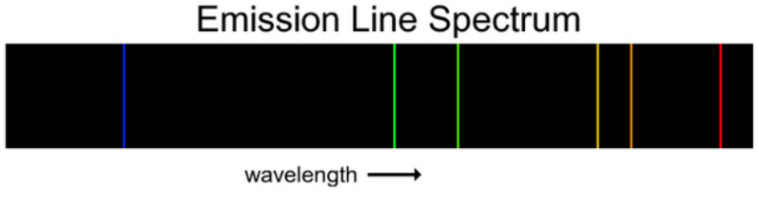
Ex: Calculate the wavelength for an e- (mass = 9.11×10^{-31} kg) at a speed of 1.0×10^{7} m/s and a ball with a mass of 0.10 kg traveling at 35 m/s

Light and electrons:

What is the difference between continuous spectrum and line emission spectrum?

What is the difference between excited light and reflected light?





Bohr Model

1) Assigned energy levels n=1 to n=7 around nucleus

2) Derived equation

$$E = -2.178 \times 10^{-18}\ J \left(\frac{Z^2}{n^2}\right)$$

Z = nuclear charge

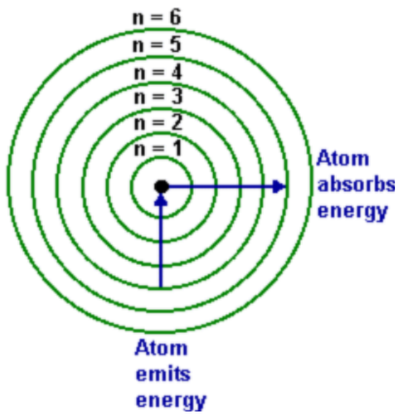
n = integer

3) Bohrs equation can calculate the energy of an e- based on its orbits (or change in energy based on its change in orbits)

Can derive Bohrs equation to an equation for Change of energy:

$$\Delta E = E_{final} - E_{initial}$$

$$\Delta E = -2.178 \times 10^{-18}\ J \left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)$$



Ex: Determine the Change in energy when an electron in hydrogen atom falls back to ground state from being in n=6. Determine the wavelength of this light.

Some math practice with our new equations:

1) Initiating most reactions involving chlorine gas involves breaking the Cl - Cl bond, which has a bond energy of 242-kJ/mol.

a) Calculate the amount of energy, in joules, needed to break a single Cl - Cl bond.

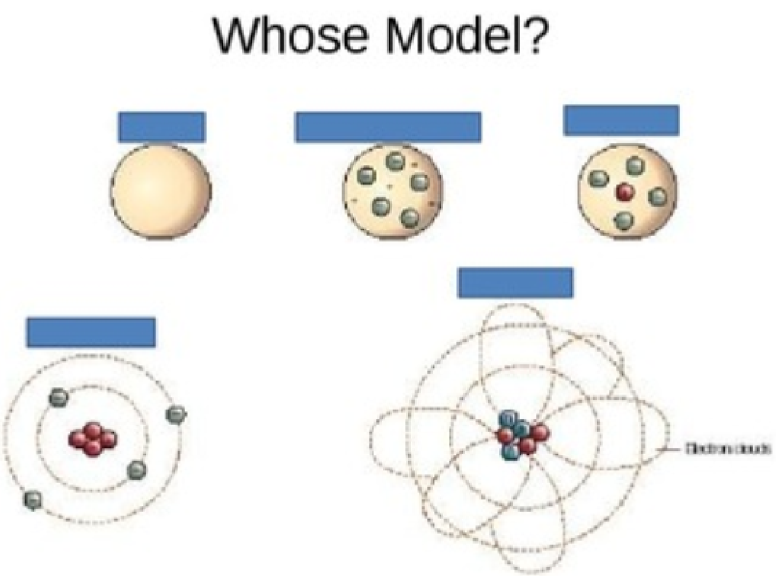
b) Calculate the longest wavelength of light, in nanometers, that can supply the energy per photon necessary to break the Cl - Cl bond.

2) The bond energy of fluorine is 159 kJ/mol
   a) Determine the energy, in J, of a photon of light needed to break a F-F bond.
   b) Determine the frequency of this photon, in s^{-1}.
   c) Determine the wavelength of this photon in nanometers.
   d) What is the wavelength of a photon resulting from the transition n = 6 to n =1?

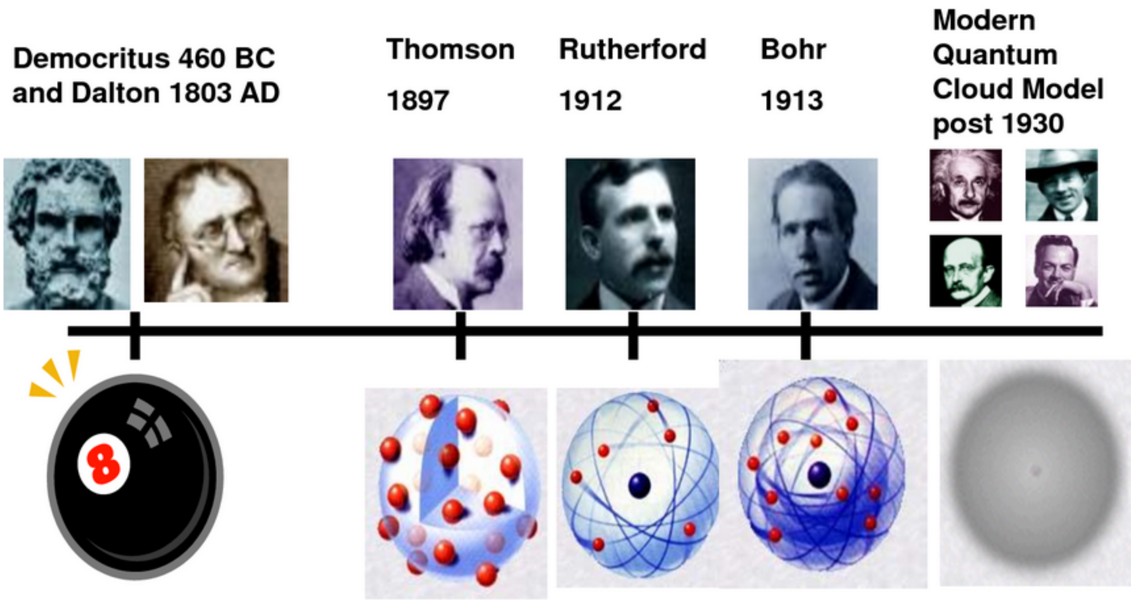
3) Hydrogen atoms absorb energy so that the electrons are excited to the energy level n = 7. Electrons then undergo these transitions (1) n = 7 to n = 1; (2) n = 7 to n = 2; (3) n = 2 to n = 1. Which of these transitions will produce the photon with:

a) the smallest energy
b) the highest frequency
c) the shortest wavelength

Atomic models



History of the Atom Timeline



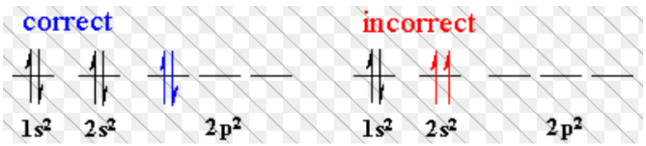
Quantum model Theory:

Heisenberg Uncertainty principle - Cannot determine velocity and location of e- simultaneously

Aufbau Principle - e- fill orbitals in lowest to highest energy

Pauli Exclusion Principle - an e- cannot have all 4 quantum #s the same (ie.: They can be in same n= level, same sublevel, same orbital but will never have the same spin also)

Hunds Rule - each orbital in a sublevel gets 1 e- before any orbital in THAT sublevel gets 2 e-



<u>Quantum Number Summary</u>:

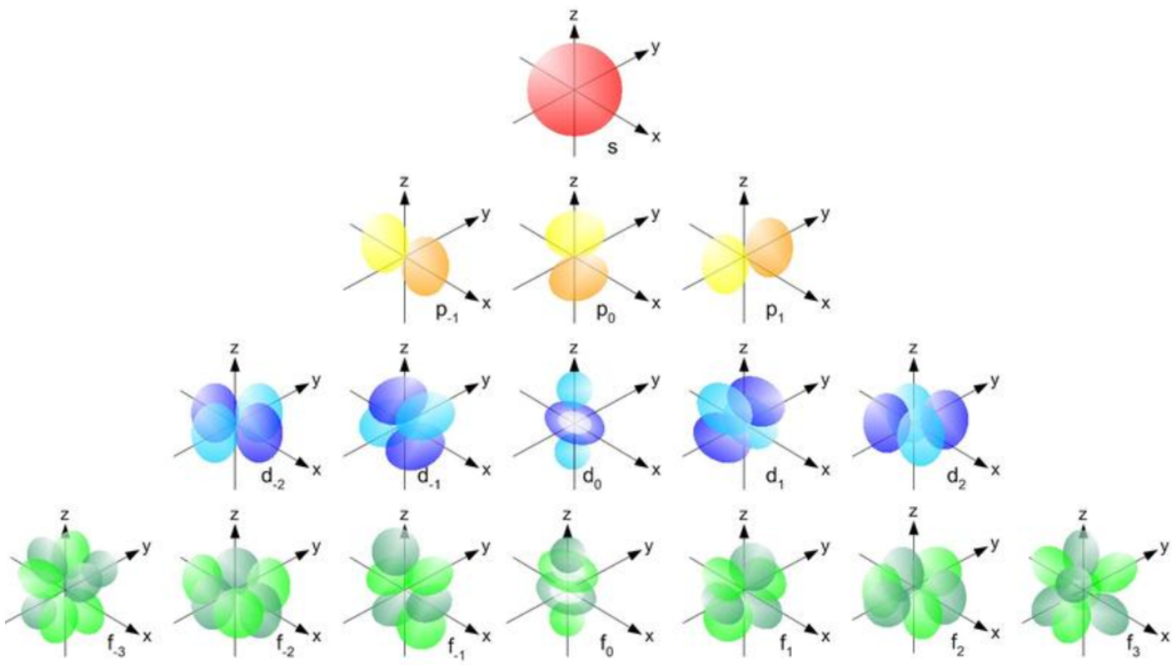
1) Principal	n	energy shells(level)	size	$n = 1, 2, 3, 4$
2) Angular momentum	l	sublevels	shape	$l = 0$ to $(n-1)$
3) Magnetic	m_l	orbitals	orientation	$m_l = -l$ to $+l$
4) Spin	m_s		spin	$m_s = +1/2, -1/2$

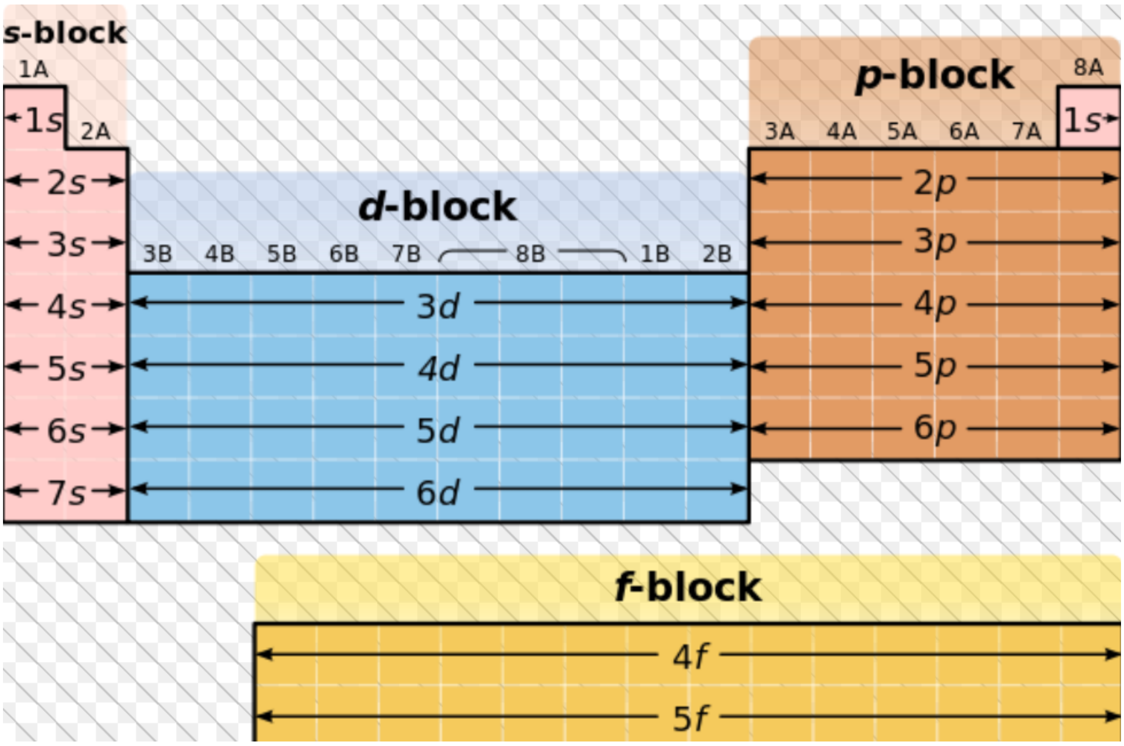
$2n^2$ = maximum number of electrons in a shell

n^2 = orbitals in a shell

$2l + 1$ = number of orientations (orbitals) in a sublevel

$l = 0$ (s) $l = 1$ (p) $l = 2$ (d) $l = 3$ (f) $l = 4$ (g)




s-block
1A
1s
2A
2s
3s
4s
5s
6s
7s
d-block
3B
4B
5B
6B
7B
8B
1B
2B
3d
4d
5d
6d
p-block
8A
3A
4A
5A
6A
7A
1s
2p
3p
4p
5p
6p
f-block
4f
5f

n shell number	l sublevel designation	m_l # of orbitals	orbital designation
1	s = 0	1	0
2	s = 0	1	0
	p = 1	3	-1, 0, 1
3	s = 0	1	0
	p = 1	3	-1, 0, 1
	d = 2	5	-2, -1, 0, 1, 2
4	s = 0	1	0
	p = 1	3	-1, 0, 1
	d = 2	5	-2, -1, 0 1, 2
	f = 3	7	-3, -2, -1, 0, 1, 2, 3

3d $\overline{-2}$ $\overline{-1}$ $\overline{0}$ $\overline{1}$ $\overline{2}$ (3,2,-2,) (3,2,-1,) (3,2,0,) (3,2,1,) (3,2,2,)

4s $\overline{0}$ (4,0,0,)

3p $\overline{-1}$ $\overline{0}$ $\overline{1}$ (3,1,-1,) (3,1,0,) (3,1,1,)

3s $\overline{0}$ (3,0,0)

2p $\overline{-1}$ $\overline{0}$ $\overline{1}$ (2,1,-1,) (2,1,0,) (2.1.1,)

2s $\overline{0}$ (2,0, 0,)

1s $\overline{0}$ (1.0,0,)

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f 6d 7p

Writing electron configurations, orbital notations, and noble gas notations:

1) Fill in order of aufbau principle
2) Follow the periodic table (like reading lines of writing in a book)
3) Remember the "exceptions" of the transition metals

   Cr Cu

   Mo Ag

4) Recall:

   Each sublevel has orbitals, each orbital can hold 2 e-

   s = _

   p = _ _ _

   d = _ _ _ _ _

   f = _ _ _ _ _ _ _

5) If writing a notation for an ion - adjust e- appropriately
6) **Lanthanide series -** occurs after lanthanum, fills the 4f

   Actinide series - occurs after actinium, fills the 5f

Quantum # Practice:

1) Give the electron configuration for tin.

2) What is the number of outer shell electrons in tin?

3) Give the complete electron configuration of silver.

4) Give the noble gas configuration of cadmium

5) How many outer shell electrons does cadmium have?

6) Give the set of quantum numbers for the 25th electron in manganese.

7) Give the set of quantum number for the last electron of silicon.

8) Give the number of electrons in Pd (palladium) that have $m_l = 1$.

9) Give the number of electrons in Co (cobalt) that have $n=3$, $m_s = -1/2$.

10) Give the electron configuration for Zn^{+2}.

11) Give the electron configuration for S^{-2}.

12) How many electrons in Sb has the quantum numbers $m_l = 0$ and $m_s = 1/2$?

13) Give the abbreviated electron configuration for the Pt^{+4}.

14) Give the set of quantum numbers for the outer shell electrons of arsenic

15) How many electrons in titanium has l = 2 and m_l = 2?

16) How many electrons in nickel has m_s = -1/2 ?

17) How many electrons in bromine has n = 2 and l = 2?

18) Write the abbreviate electron configuration for the following ions:

A) Cu^{+2}

B) Ca^{+2}

C) Mn^{+2}

D) Zn^{+2}

Periodic Trends:

		Down a group	Across a period (L → R)
1)	**Atomic Size**	Increase	Decrease
	Why?	Add Shells as period # increases	In same sublevel proton # increase, but energy level to outer e- stays same

Comparative sizes of ions:

Cation vs Atom Ex: Na vs Na+

Why? Proton vs e- count and loss of n level

Anion vs Atom Ex: Cl vs Cl-

Why? Electron Repulsion

Isoelectronic - have the same number of total electrons

Ex: Place the following isoelectronic ions in order of increasing radius (size)

S^{-2} P^{-3} K^{+}

2) **Ionization energy (IE)**

The energy needed to remove an electron from a gaseous particle

Ex: $Mg_{(g)} + IE_1 \text{ ---> } Mg^{+1} + e^-$

$IE_2 > IE_1$

$Mg^{+}_{(g)} + IE_2 \text{ ----> } Mg^{+2}_{(g)} + e^-$

$IE_3 >>> IE_2 > IE_1$

$Mg^{+2}_{(g)} + IE_3 \text{ ----> } Mg^{+3}_{(g)} + e^-$

What is the size comparison of these 3 resultant particles?

Trend of IE	**Down Group**	**Across Period (L---> R)**
	Decrease	Increase

Ex: Which atom would have the greater ionization energy?

As or Se?

Ex: Consider atoms with the electron configurations of

$1s^2 2s^2 2p^6$

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

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

Which has the largest 1st ionization energy and which has the smallest 2nd ionization energy?

Ex: Consider the IE of aluminum and its ions. Explain the large jump between IE_3 and IE_4

$Al_{(g)} \text{ ---> } Al^{+1}_{(g)} + 1e^-$	IE = 580 kJ/mol
$Al^{+1}_{(g)} \text{ ---> } Al^{+2}_{(g)} + 1e^-$	IE = 1815 kJ/mol
$Al^{+2}_{(g)} \text{ ---> } Al^{+3}_{(g)} + 1e^-$	IE = 2740 kJ/mol
$Al^{+3}_{(g)} \text{ ---> } Al^{+4}_{(g)} + 1e^-$	IE = 11,600J/mol

3) **Electron Affinity**

- The energy <u>change</u> that occurs when an electron is added to a particle

Ex: Cl(g) + e- ---> Cl- + EA
(exothermic)

Trends	**Down a Group**	**Across a period (L--> R)**
Electron Affinity	IE becomes more (+), less likely to occur	Increase in (-) exothermic value

Ex: For the following elements, pick the atom with the

a) More favorable (exothermic) electron affinity

b) Higher IE

c.) Larger size

K Cl S

4) **Electronegativity -** strength of attraction of an atom toward another atom's e-

Trend	**Down a group**	**Across a period (L ---> R)**
	Decreases	Increases

Ex: Place the following in order of increasing electronegativity

Si O Te Cl

Trends of Groups:

1) Most groups behave very similarly - valence e- count

2) Group 1:

   a) Most chemically reactive metals

   b) H is not an alkali, it is here b/c it has 1 valence e-

   c) Trends of group 1 http://www.youtube.com/watch?v=uixxJtJPVXk

   Density increase (going down group)

   Decrease in MP/BP (going down a group)

   d) All group 1 metals oxidize readily, so they are good Reducing Agents

   Cs > Rb > K > Na > Li

   e) Group 1 also reacts with WATER vigorously

   Li > K > Na (Notice different strength of rxn with water)

Arrange in increasing electronegativity:

1) S, F, Se, O

2) O, Na, N, Rb, F, Mg

3) As, F, P, Sb, O

Choose the one with the highest IE:

1) Na, P, Cl, Al

2) Na, K, Rb, Li, Cs

3) N, Cl, O, C, F, Br

4) C, F, N, O

5) Ca, Mg, Be, Sr, Ba

Explain the following trend:

order of increasing ionization energy: Si < S < P

Arrange in Increasing size:

1) Cs, Mg, K, Na, Rb

2) F, O, Ne, S, As

3) P, F, N, O, As

<u>Give which is the smallest:</u>

1) Br or Br^-

2) K or K^+

3) S^{-2} , Cl^-, Br^-

4) Na, Na^+ , Mg, Mg^{+2} , Ca, Ca^{+2}

ARRANGE IN INCREASING SIZE:

A) Cs, Mg, K, Na, Rb

B) F, O, Ne, S, As

C) P, F, N, O, As

CHOOSE THE ONE WITH THE HIGHEST IONIZATION ENERGY:

A) Na, P, Cl, Al
B) Na, K, Rb, Li, Cs
C) N, Cl, O, C, F, Br
D) C, F, N, O
E) Ca, Mg, Be, Sr, Ba

ARRANGE IN INCREASING ELECTRONEGATIVITY:

A) S, F, Se, O

B) O, Na, N, Rb, F, Mg

C) As, F, P, Sb, O

GIVE WHICH IS THE SMALLEST:

A) Cl, Cl^-

B) Na, Na^{+1}

C) S^{-2}, Cl^{-1}, Br^{-1}

D) Na, Na^{+1}, Mg, Mg^{+2}, Ca, Ca^{+2}