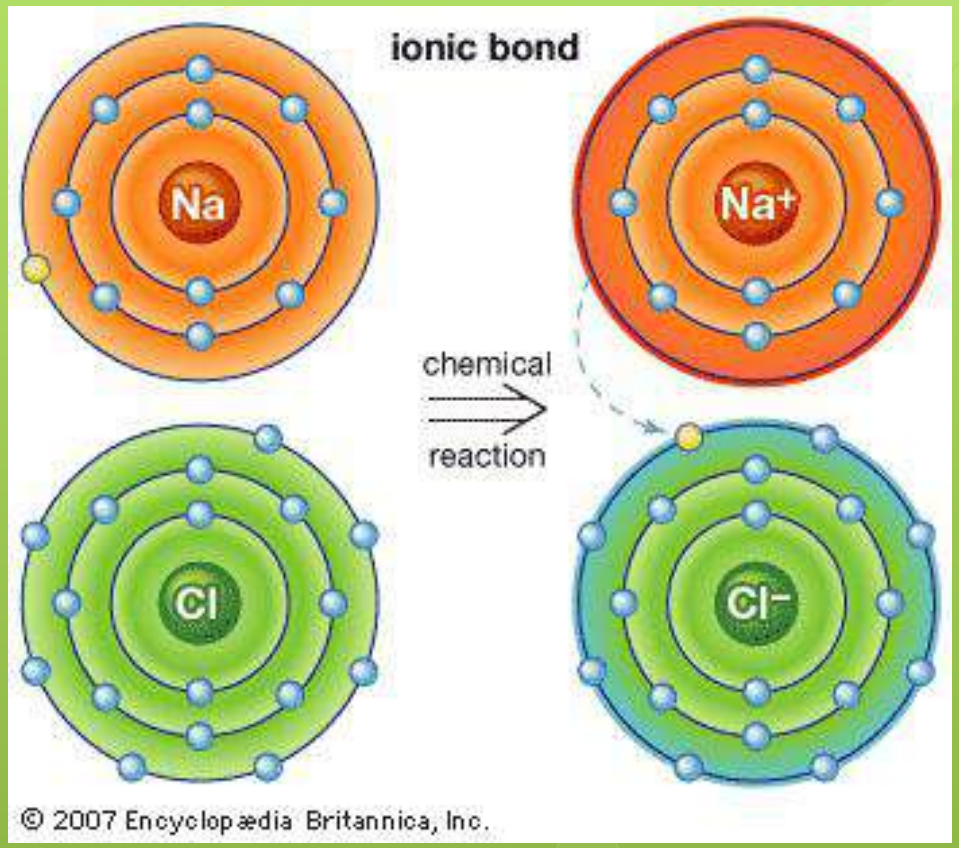
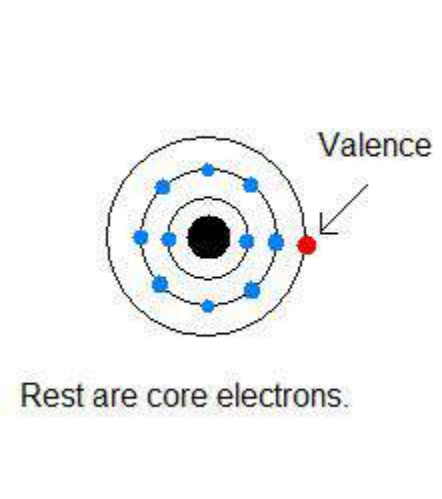
Chapter 7 – Ionic and Metallic Bonding

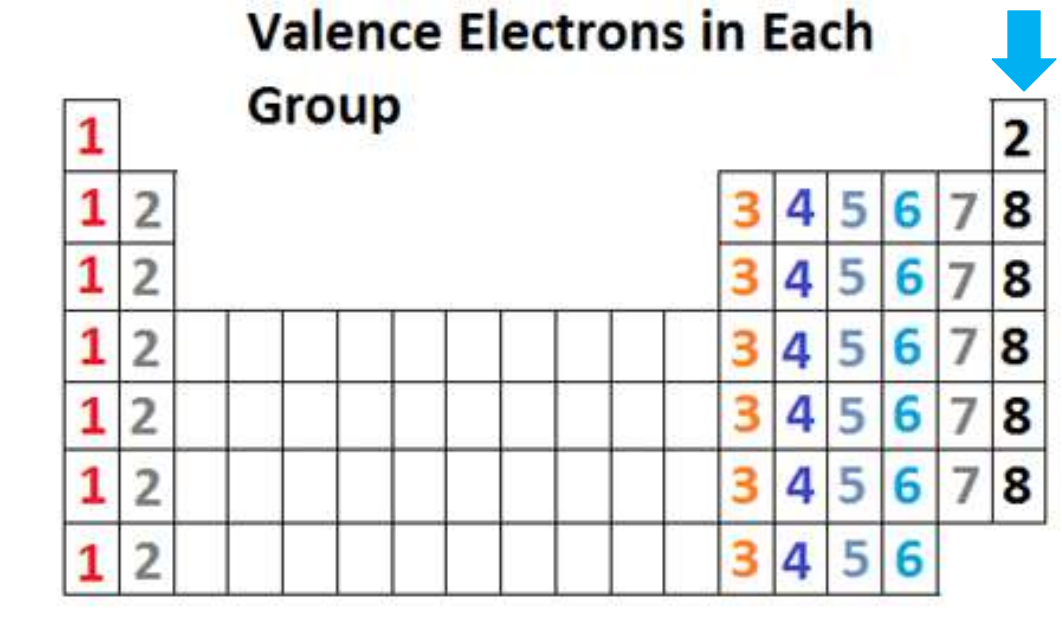


Augustine

Section 7.1 - Ions

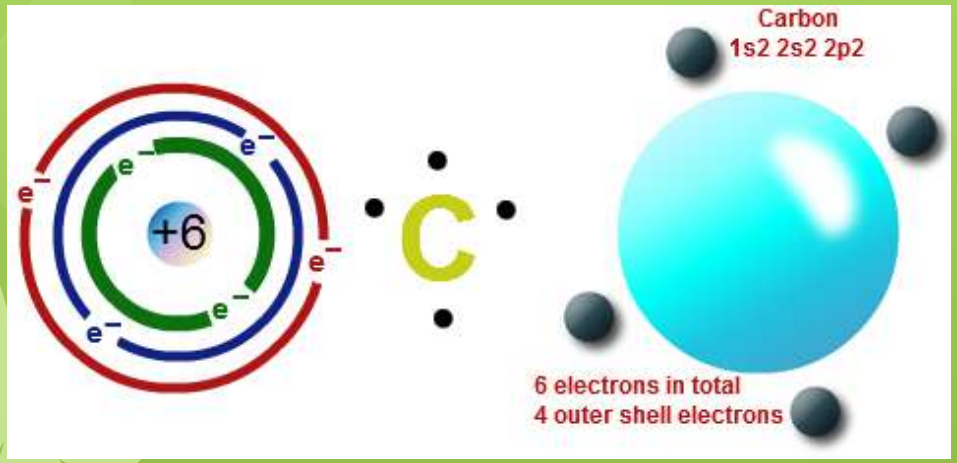
- Valence electrons are the electrons in the highest occupied energy level.
- Valence electrons are the only electrons involved in chemical bonding.
- Elements in the same group have the same number of valence electrons.

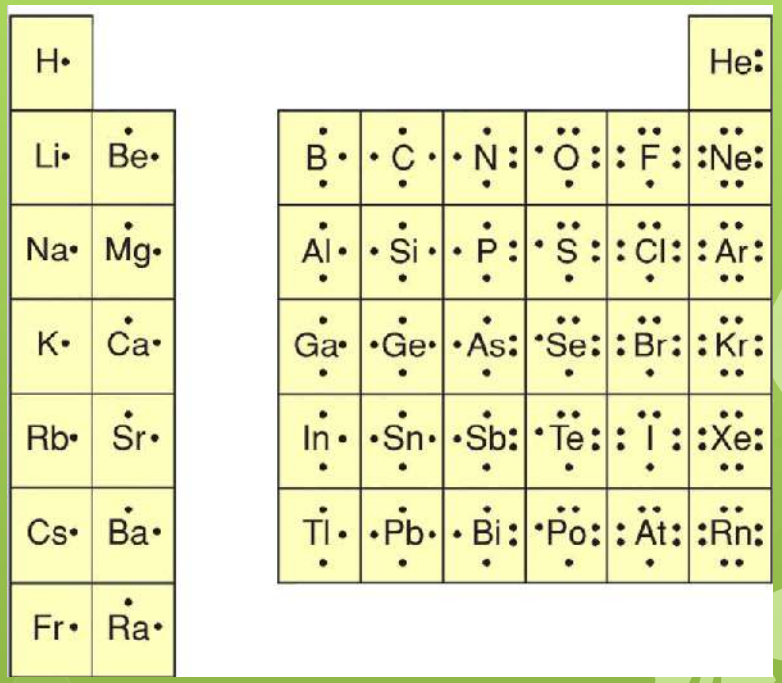




Electron Dot Structures

- Electron dot structures are diagrams that show the symbol of the element surrounded by the valence electrons as dots.





Practice Problems

- Write the electron dot structure for the following elements:

P

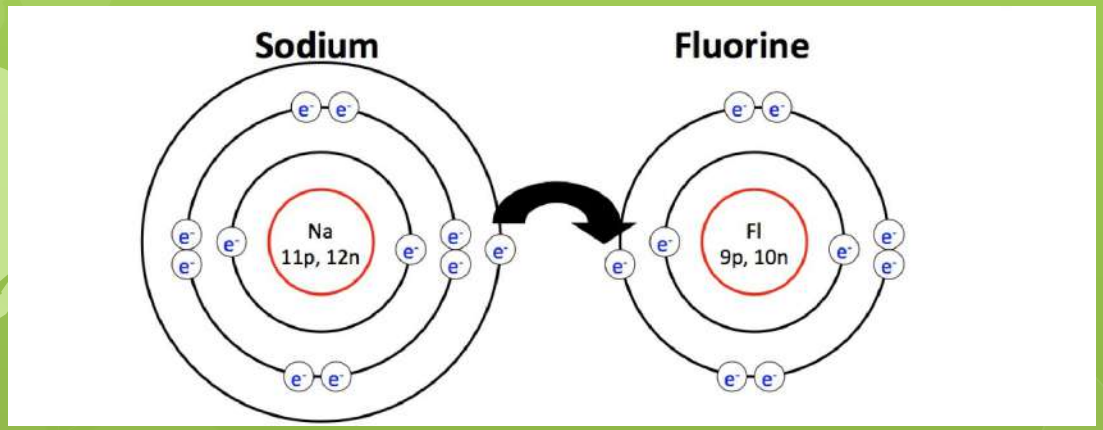
Ar

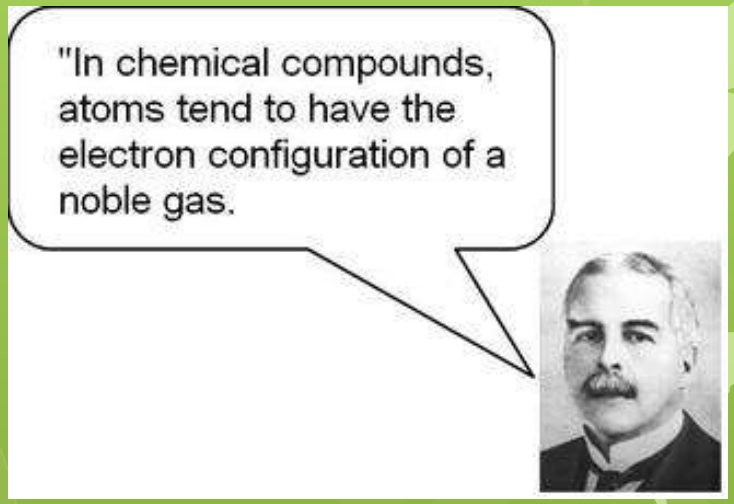
Mg

He

Octet Rule

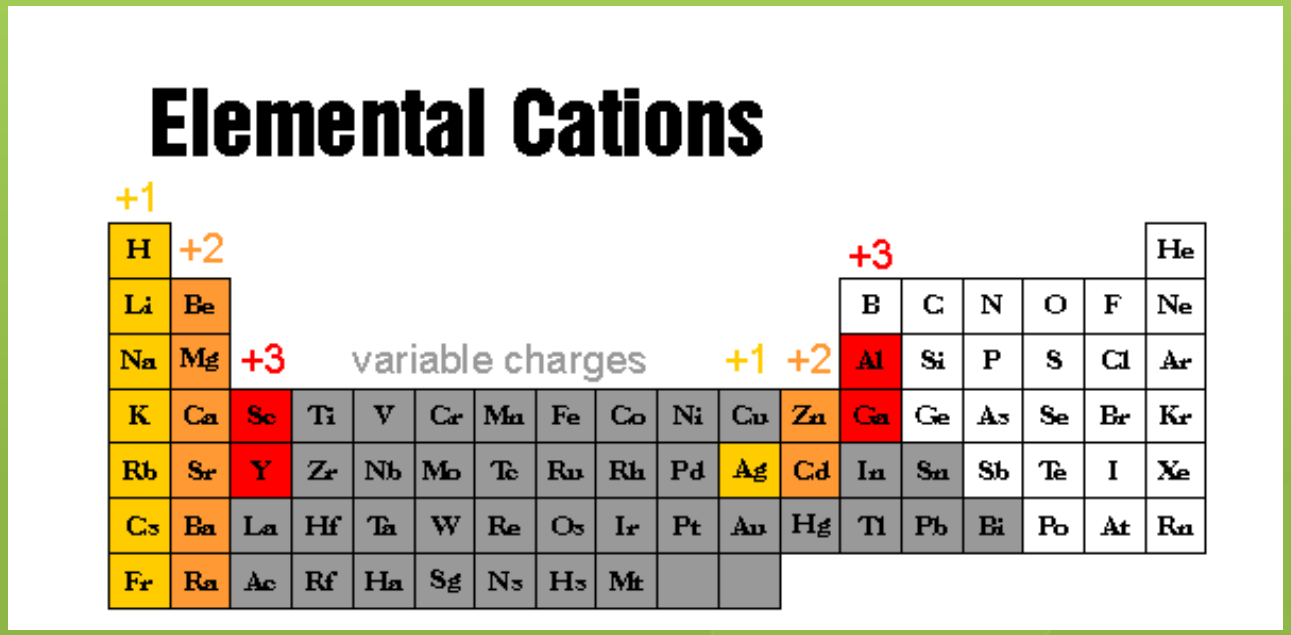
- The octet rule states that atoms tend to achieve a stable configuration when they have 8 valence electrons.
- Metals tend to lose electrons to achieve noble-gas configuration. Nonmetals tend to gain electrons to achieve noble-gas configuration.





Cations

- A cation ion is a positive ion that has lost electrons.
- When writing the electron configuration for a cation, write the electron configuration for the atom and then subtract the electrons from the highest energy level.
- When you name a cation, the name of the element does not change. Ex: Ca^{+2} = calcium ion



Sample Problem

- Write the electron configuration and name for the following:

- Sr^{2+}

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

Strontium ion

- Fe^{+3}

$1s^2 2s^2 2p^6 3s^2 3d^5$

Iron ion

Practice Problems

- Write the electron configurations and the name for the following:

- Zn^{+2}

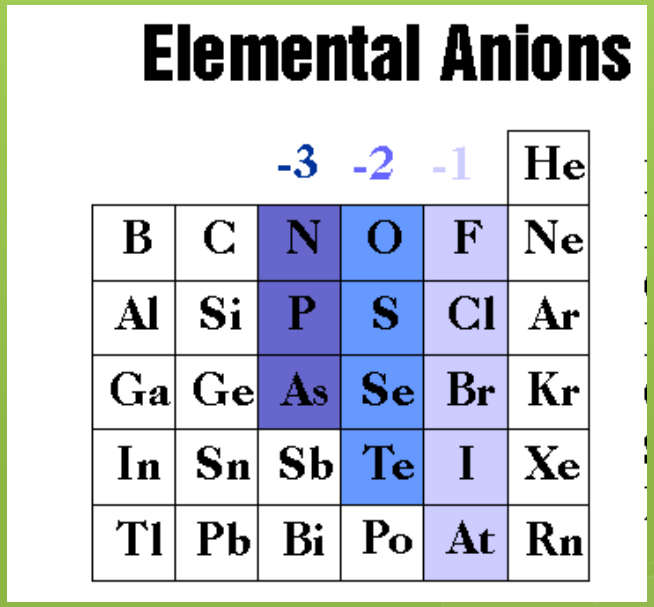
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
Zinc ion

- Na^{+}

$1s^2 2s^2 2p^6$
Sodium ion

Anions

- Anions are negatively charged ions that have gained electrons.
- When writing the electron configuration for anions, write the electron configuration for the atom and then add the correct number of electrons.
- When naming an anion, you change the ending of the element to –ide. Ex: Cl^- = chlor**ide** ion



Sample Problems

- Write the electron configuration and name for the following:

- P^{-3}

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

- F^-

$1s^2 2s^2 2p^6$
Fluoride ion

Practice Problems

- Write the electron configuration and name for the following:

- Br^-

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

- S^{-2}

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

Section 7.1 Assessment

1. How can you determine the number of valence electrons in an atom of a representative element?
2. Atoms of which elements tend to gain electrons? Atoms of which elements tend to lose electrons?
3. How do cations form?
4. How do anions form?
5. How many valence electrons are in each atom?
   a. Potassium
   b. Carbon
   c. Magnesium
   d. Oxygen
6. Draw the electron dot structure for each element in question 5.

Section 7.1 Assessment

7. How many electrons will each element gain or lose in forming an ion?

    a. calcium

    b. fluorine

    c. aluminum

    d. oxygen

8. Write the name and symbol of the ion formed when

    a. a potassium atom loses one electron.

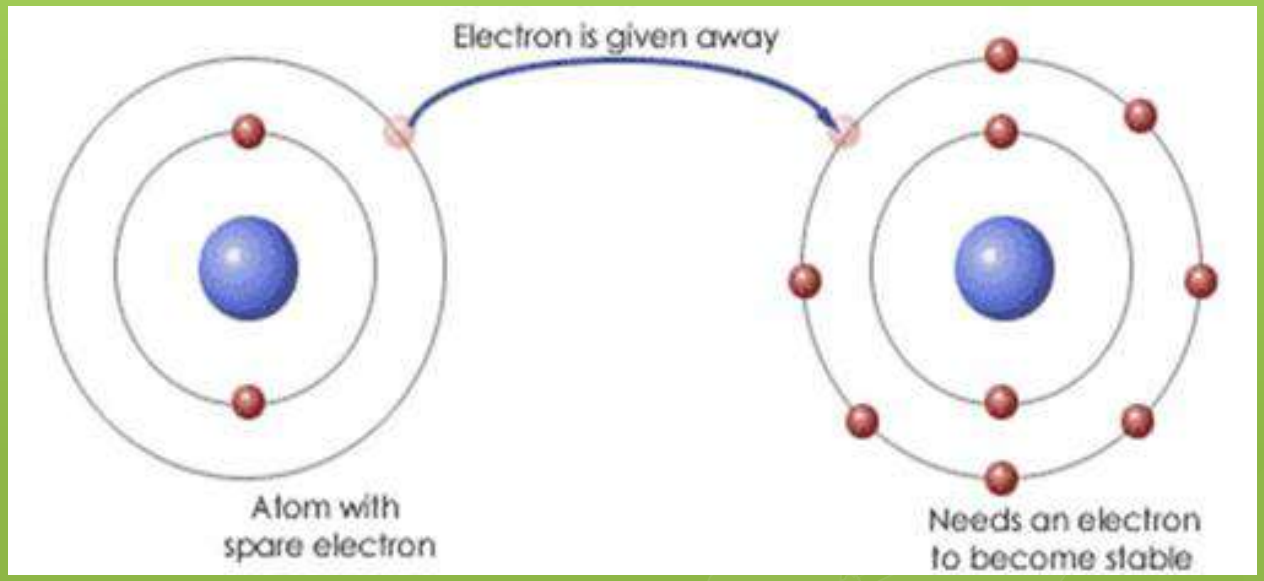
    b. a zinc atom loses two electrons.

    c. a fluorine atom gains one electron.

9. Write the electron configuration of Cd^{+2}.

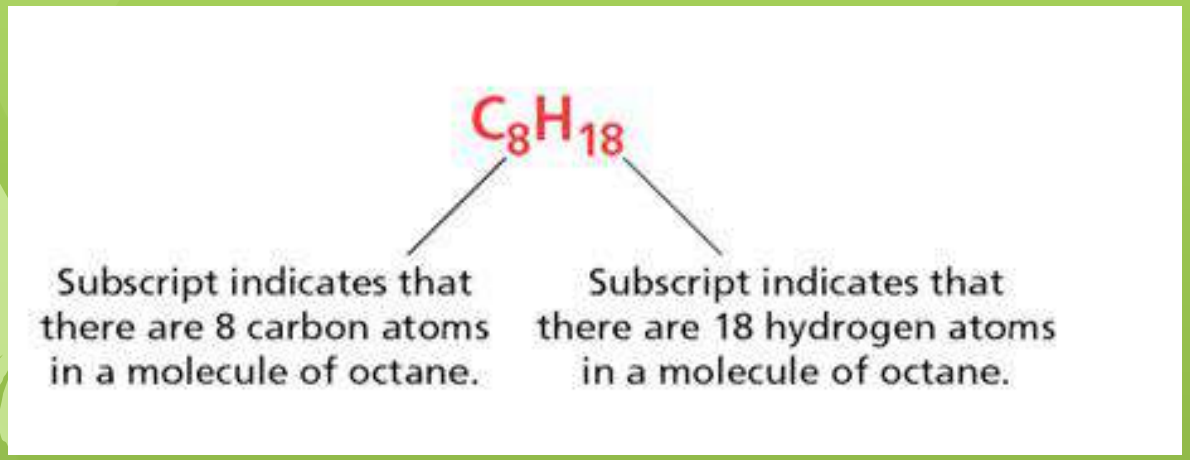
Section 7.2 – Ionic Bonds and Ionic Compounds

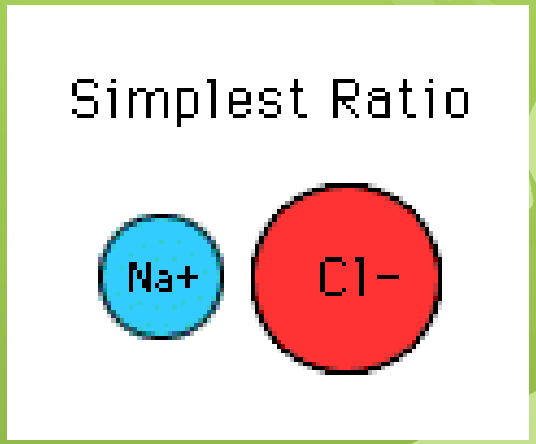
- Compounds composed of cations and anions are called ionic compounds.
- Although they are composed of ions, ionic compounds are electrically neutral.
- The electrostatic forces that hold ions together are called ionic bonds.



Formulas

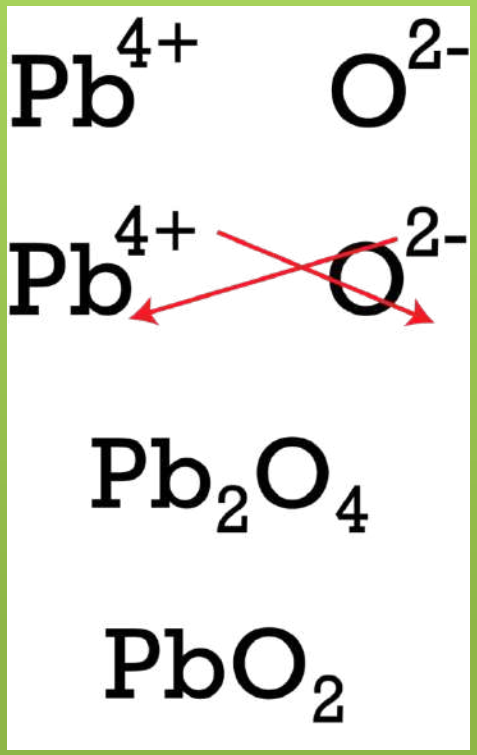
- A chemical formula shows the kinds and numbers of atoms in the smallest representative unit of a substance.
- A formula unit is the lowest whole-number ratio of ions in an ionic compound.

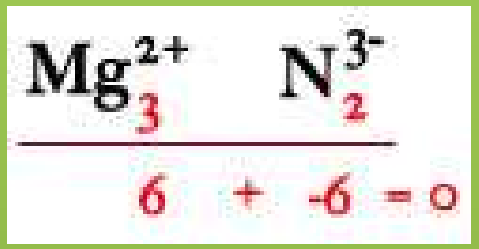




Balancing Charges

- When you balance charges to write the formula for an ionic compound, you must make the + charge and – charge equal by adding subscripts.
- The subscripts must be in the lowest ratio to be correct.





Sample Problems

- Write the formula for the compound formed between the following elements.

- Potassium and oxygen

K_2O

- Magnesium and nitrogen

Mg_3N_2

Practice Problems

- Write the formula for the compound when the following elements combine.

- Potassium and iodine

  KI

- Aluminum and oxygen

  Al_2O_3

- Calcium and chlorine

  $CaCl_2$

- Barium and sulfur

  BaS

Polyatomic Ions

- Polyatomic ions are a group of atoms with an overall charge.
- When balancing charges for polyatomic ions, you follow the same rule of cancelling the + and – charge.
- However, if you need to add a subscript to a polyatomic ion, then you have to put the polyatomic ion in parentheses. Ex: $Ca(NO_3)_2$

Common Polyatomic Ions			
$C_2H_3O_2^-$	acetate	OH^-	hydroxide
NH_4^+	ammonium	ClO^-	hypochlorite
CO_3^{2-}	carbonate	NO_3^-	nitrate
ClO_3^-	chlorate	NO_2^-	nitrite
ClO_2^-	chlorite	$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate	ClO_4^-	perchlorate
CN^-	cyanide	MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate	PO_4^{3-}	phosphate
HCO_3^-	bicarbonate	SO_4^{2-}	sulfate
HSO_4^-	bisulfate	SO_3^{2-}	sulfite
HSO_3^-	bisulfate		

Sample Problems

- Write the formula for the compound when the following ions combine:

- Sodium and phosphate

Na_3PO_4

- Ammonium nitride

$(NH_4)_3N$

- Aluminum carbonate

$Al_2(CO_3)_3$

Practice Problems

- Write the formula for the compound when the following ions combine:

- Barium nitrate

$Ba(NO_3)_2$

- Lithium phosphate

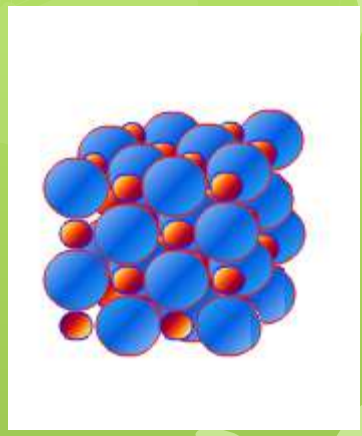
Li_3PO_4

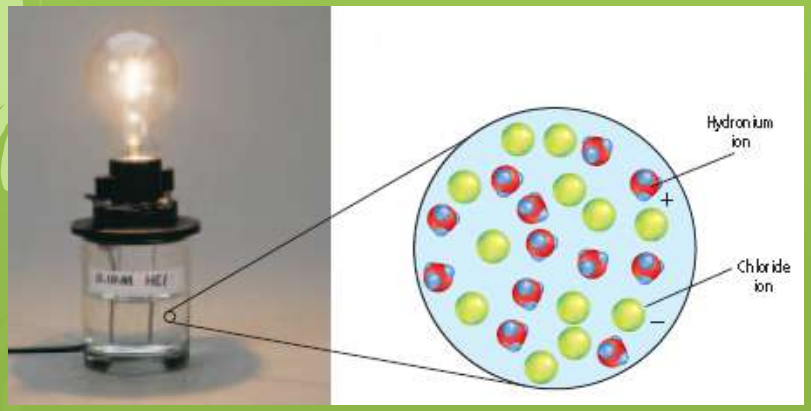
- Strontium sulfite

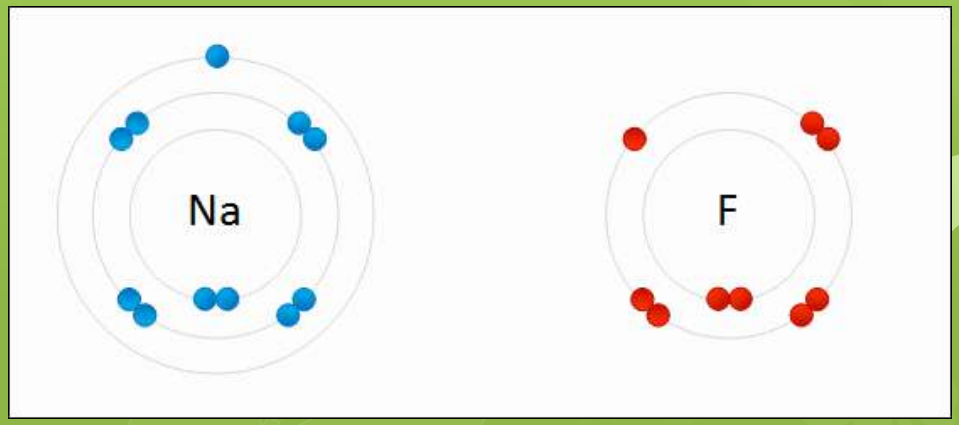
$SrSO_3$

Properties of Ionic Compounds

- Properties of ionic compounds include the following:
- Crystalline solids
- High melting points
- Conduct electricity when molten or aqueous
- Made of metals and nonmetals
- Made of cations and anions
- Made of ionic bonds

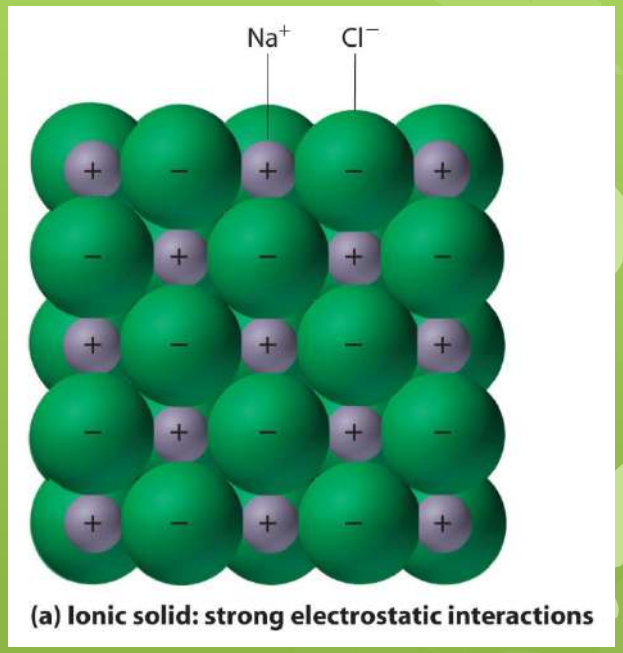






Crystals

- A crystal is a substance with a 3-D repeating arrangement of particles called the crystal lattice.
- The coordination number of an ion is the number ions of opposite charge that surround the ion in a crystal.



Section 7.2 Assessment

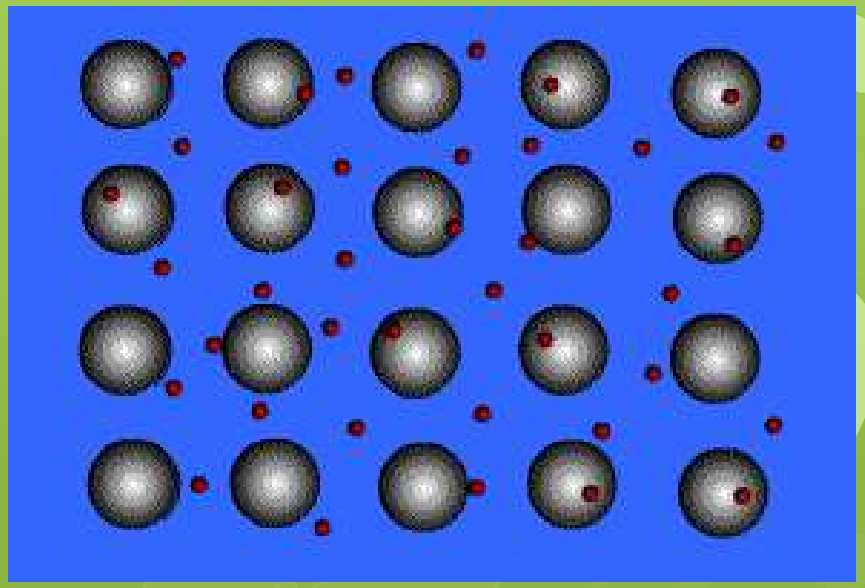
1. How can you describe the electrical charge of an ionic compound?
2. What properties characterize ionic compounds?
3. Write the correct chemical formula for the compounds formed by each pair of ions.
   a. K^{+}, S^{-2}
   b. Ca^{+2}, O^{-2}
   c. Na^{+}, O^{-2}
   d. Al^{+3}, N^{-3}

Section 7.2 Assessment

4. Write formulas for each compound.
   a. barium chloride
   b. Magnesium oxide
   c. Lithium oxide
   d. Calcium fluoride
5. Which pairs of elements are likely to form ionic compounds?
   a. Cl, Br
   b. Li, Cl
   c. K, He
   d. I, Na

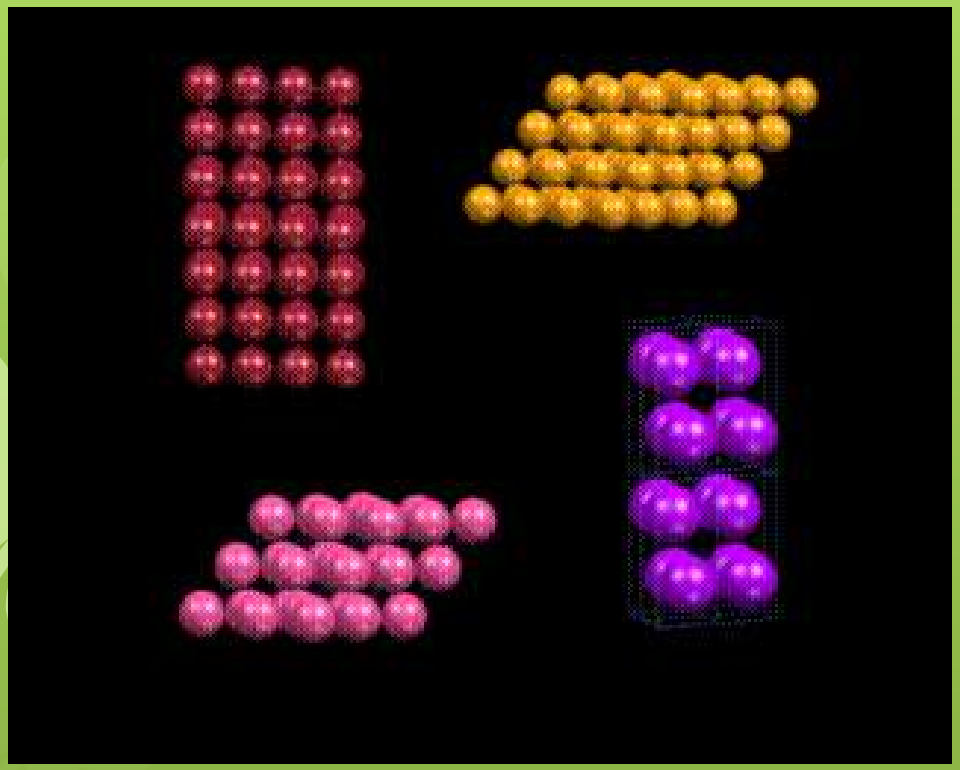
Section 7.3 – Bonding in Metals

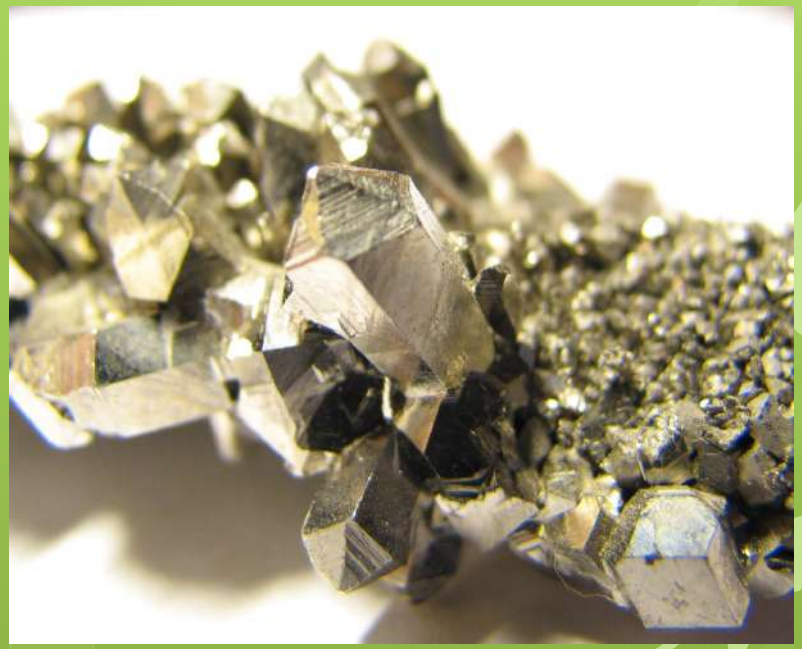
- The valence electrons of metal atoms can be modeled as a sea of electrons.
- Metallic bonds consist of the attraction of the free-floating valence electrons for the positively charged metal ions.
- Metals are good conductors and malleable because of their mobile electrons.



Metals

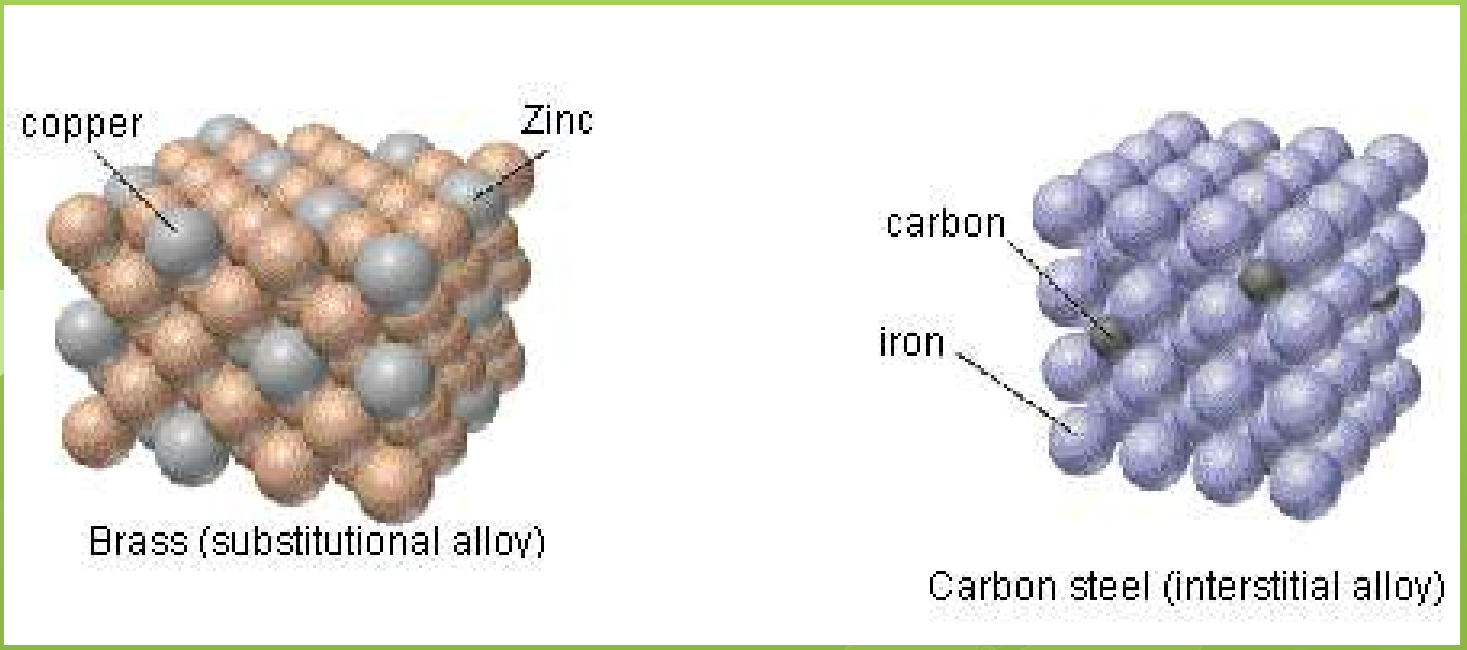
- Metals are the most simple crystals because they contain one type of element.





Alloys

- An alloy is a mixture with metallic properties.
- A substitutional alloy is made when atoms of one metal replace atoms of another metal.
- An interstitial alloy is made when smaller metal atoms are inserted in between larger metal atoms.

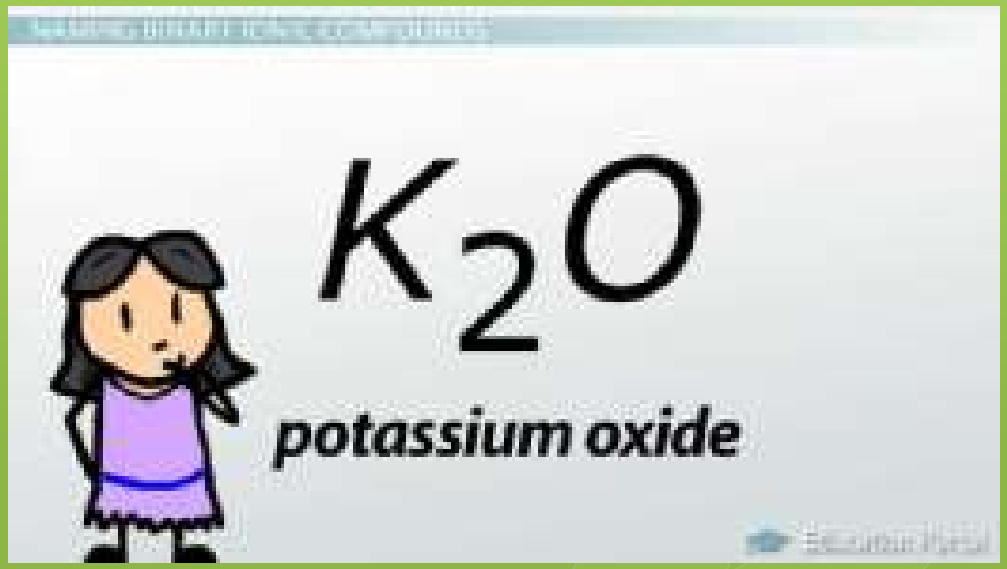


Section 7.3 Assessment

1. How do chemists model the valence electrons in metal atoms?
2. How can you describe the arrangement of atoms in metals?
3. Why are alloys more useful than pure metals?
4. Describe what is meant by ductile and malleable.

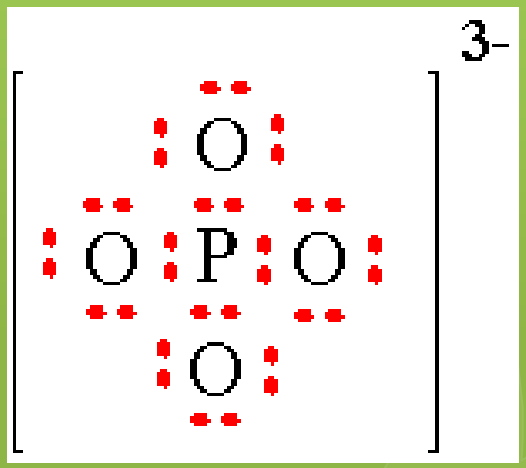
Section 9.1 – Naming with Regular Metals

- A monatomic ion is a single atom with a charge. Ex: Na^{+} or O^{-2}
- When naming a cation, the name of the element does not change. Ex: K^{+} = potassium
- When naming an anion, the ending of the element changes to –ide. Ex: O^{-2} = ox**ide**

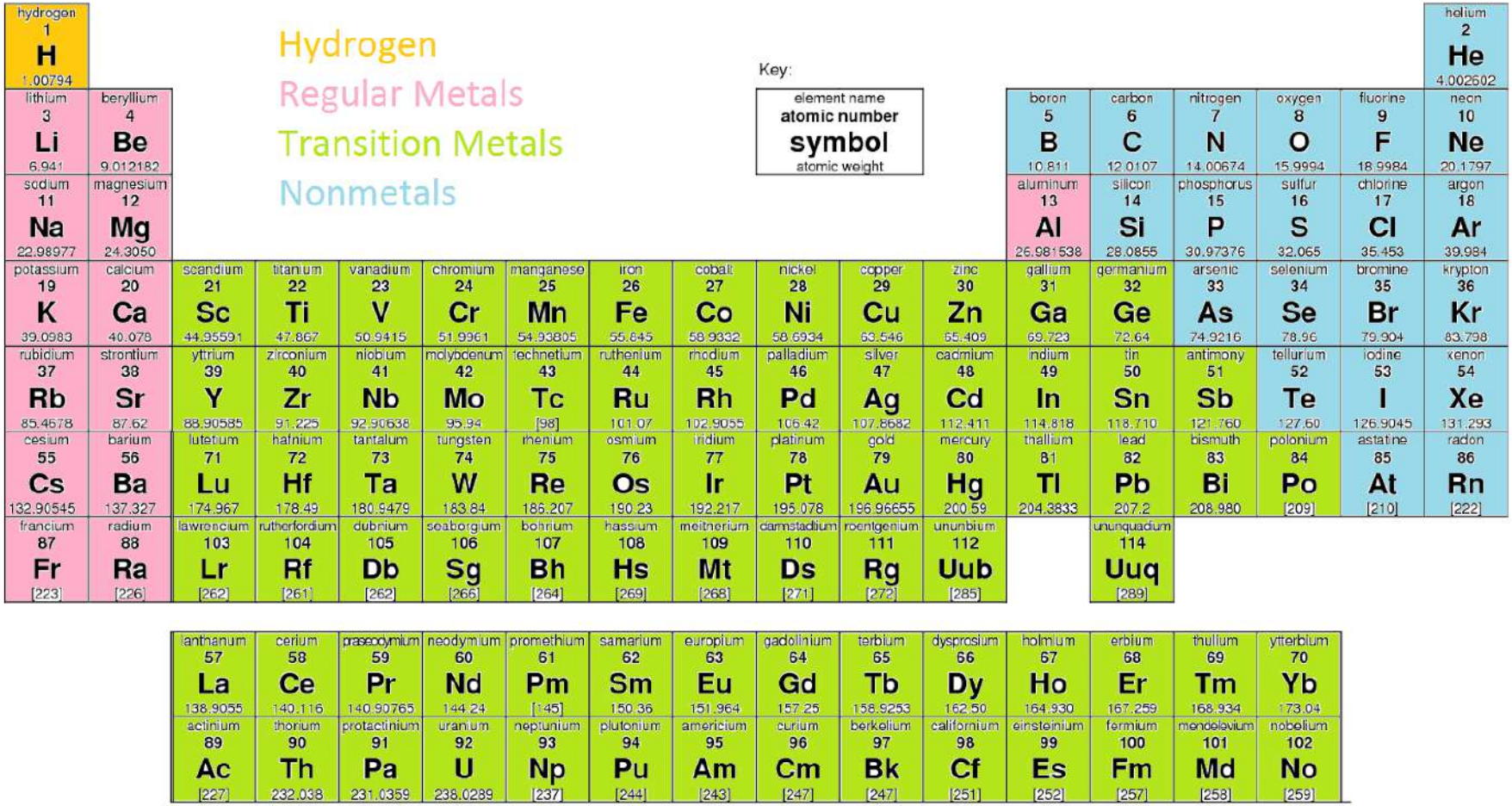


Polyatomic Ions

- A polyatomic ion is a group of atoms with an overall charge. Ex: SO_4^{-2}
- Most polyatomic ions end in –ate or –ite. The ending does not change when naming a compound (unless it is an acid which we will talk about later).
- The –ate suffix indicates that the polyatomic ion contains one more oxygen than the polyatomic ion with the –ite suffix. (Ex: sulfate = SO_4^{-2}, sulfite = SO_3^{-2})

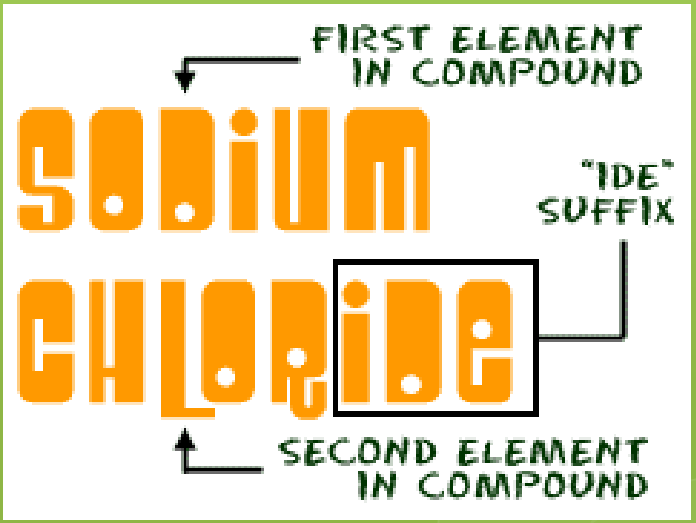


Periodic Table for Naming



Naming with Regular Metals

- The regular metals are located in groups 1 and 2 (except for H). Aluminum is also a regular metal.
- When naming a compound that starts with a regular metal, you name the metal (cation) and add –ide to the nonmetal (anion). Ex: NaCl = sodium chlor**ide**
- If the anion is a polyatomic ion, then you do not change the ending. Ex: $CaCO_3$ = calcium carbonate



Sample Problems

- Name the following compounds:

- Na_2O

  Sodium oxide

- $AlBr_3$

  Aluminum bromide

- Li_2SO_4

  Lithium sulfate

Practice Problems

- Name the following compounds:

- $LiNO_3$

  Lithium nitrate

- $Ca_2(PO_4)_3$

  Calcium phosphate

- $(NH_4)_2O$

  Ammonium oxide

Writing the Formula with Regular Metals

- When writing the formula of a compound that starts with a regular metal, you must BALANCE THE CHARGES.

- Ex: aluminum bromide

  AlBr

  balance charges

  $Al^{+3}Br^{-}$

  $AlBr_3$

cation	anion	compound
Ca^{+2}	Cl^{-1}	$CaCl_2$
Ba^{+2}	O^{-2}	BaO
K^{+1}	S^{-2}	K_2S
Fe^{+3}	Br^{-1}	$FeBr_3$
Cr^{+3}	O^{-2}	Cr_2O_3

Sample Problems

- Write the formula for the following compounds:

- Aluminum chloride

$AlCl_3$

- Calcium acetate

$Ca(C_2H_3O_2)_2$

- Lithium fluoride

LiF

Practice Problems

- Write the formula for the following compounds:

- Calcium carbonate

$CaCO_3$

- Aluminum oxide

Al_2O_3

- Cesium oxalate

$Cs_2C_2O_4$

Section 9.1 Assessment

1. What are the usual ending for the names of polyatomic ions?
2. How does a polyatomic ion differ from a monatomic ion?
3. Write the formula for these binary compounds.
    a. Beryllium chloride
    b. Cesium sulfide
    c. Sodium iodide
    d. Strontium oxide

Section 9.1 Assessment

4. Write the formula for these compounds.
   a. sodium perchlorate
   b. magnesium hydrogen carbonate
   c. calcium acetate
5. Identify any incorrect formulas. Explain your answer.
   a. $Mg_2(SO_4)_3$
   b. Rb_3As
   c. $BeCl_3$
   d. NaF

Section 9.2 – Naming with Transition Metals

- Transition metals can have multiple charges, so you cannot tell the charge based on the group it is in.
- Since transition metals can have multiple charges, we use a roman numeral to indicate the charge.
- Review of Roman Numerals

  1 = I

  2 = II

  3 = III

  4 = IV

  5 = V

  **You should not use a roman numeral over 5.

Transition Metals

- When naming compounds that start with a transition metal, you should balance charges to figure out the charge of the transition metal.
- Remember add –ide to the anion if it is not a polyatomic ion.

- Ex: CuO

  we know that O has a -2 charge.

  CuO^{-2}

  to cancel out a -2, Cu must be +2

  $Cu^{+2}O^{-2}$

  so the name would be copper (II) oxide.

Sample Problems

- Write the names for the following:

- Cu_2O

  Copper (I) oxide

- $FeCl_3$

  Iron (III) chloride

- $PbSO_4$

  Lead (II) sulfate

Practice Problems

- Write the name of the following:

- PbS_2

  Lead (IV) sulfide

- $Zn(C_2H_3O_2)_2$

  Zinc (II) acetate

- Ag_3PO_3

  Silver (I) phosphite

Old Names for Transition Metals

- For the old naming system for transition metals, the old Latin names are used with the suffix –ic or –ous.

Ion	Old Name
Fe^{3+}	ferric
Fe^{2+}	ferrous
Cu^{2+}	cupric
Cu^{+}	cuprous
Co^{3+}	cobaltic
Co^{2+}	cobaltous
Sn^{4+}	stannic
Sn^{2+}	stannous
Pb^{4+}	plumbic
Pb^{2+}	plumbous
Hg^{2+}	mercuric
Hg_2^{2+}	mercurous

Old Names for Transition Metals

- The –ic ending indicates a higher charge, and the –ous ending indicates a lower charge.
- When writing the name for a compound, you figure out the charge for the transition metal and then find the old name on the chart.
- Ex: FeS

  $Fe^{+2}S^{-2}$

  Fe^{+2} = ferrous

  FeS = ferrous sulfide

Practice Problems

- Write the old names for the following:
- Cu_3P

  Cuprous phosphide
- $Fe(NO_3)_3$

  Ferric nitrate
- PbS

  Plumbous sulfide

Writing the Formulas for Transition Metals

- When writing the formula for a compound that starts with a transition metal, you must BALANCE THE CHARGES.

- Ex: vanadium (V) fluoride

  VF

  balance charges

  $V^{+5}F^{-}$

  VF_5

REMEMBER THE ROMAN NUMERAL IS THE CHARGE, NOT THE SUBSCRIPT!!!!!!!!!!!!!!!

Sample Problems

- Write the formula for the following:

- Tin (II) permanganate

$Sn(MnO_4)_2$

- Mercury (I) oxide

Hg_2O

- Cobaltic carbonate

$Co_2(CO_3)_3$

Practice Problems

- Write the formula for the following:
- Gold (II) iodide

AuI_2

- Vanadium (IV) nitrite

$V(NO_2)_4$

- ferrous chromate

$FeCrO_4$

Section 9.2 Assessment

1. Write the formula for chromium (III) nitrite.

THE END