

IONIC COMPOUNDS

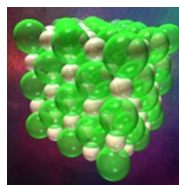
- All are solids at SATP (Standard Ambient Temperature and Pressure) of 25°C and 100 kPa.
- When they dissolve in water, they form *aqueous* solutions that are colored or colorless and conduct electricity i.e. they are **electrolytes**
- These compounds form after an electron transfer: *from a metal to a nonmetal*
- the resulting ions (cations and anions) are attracted to each other (since they are oppositely charged) and they form **ionic bonds**

metal / non metal = Ionic

http://www.youtube.com/watch?v=xTx_DWboEVs&feature=related

Sep 13-1:17 PM

- Together all of the ions present form an **ionic crystal lattice** in which the net charge is zero



- Eg: (1) in a sample of sodium chloride, NaCl, for every Na ion there is one Cl⁻ ion
- Eg: (2) in a sample of calcium chloride, CaCl₂, for every

Ca²⁺ ion there are 2 Cl⁻ ions

- **Formula Unit:** an expression of the simplest whole number ratio of cations to anions

Eg: NaCl 1:1 Ratio of Na⁺ : Cl⁻

CaCl₂ 1:2 Ratio of Ca²⁺ : Cl⁻

Sep 13-1:18 PM

<http://www.youtube.com/watch?v=QqjCvzWwww&feature=related>

Types of Ions and Ionic Compounds**A. Monatomic Ions (Simple Ions)**

- Single atoms that have lost or gained one or more electrons
- Form *Binary Ionic Compounds* (2 simple ions)

Binary Ionic Compounds

Metals and nonmetals combine to form ionic compounds by transferring electrons. The result is a compound that is electrically neutral. The sum of the charges on the positive ion equals the sum of the charges on the negative ions. Ex Na⁺ Cl⁻

Nov 22-10:11 PM

Sep 13-1:19 PM

Ex 1: Name the compound and chemical formula for the combination of aluminum (metal) and chlorine (nonmetal).

Ex2: Write the chemical formulas.

a) Silver chloride c) potassium oxide

b) ~~Aluminum~~ ^{Barium} sulfide d) Magnesium chloride

Nov 23-9:07 PM

Nov 23-9:06 PM

Ex3: Write the names for the following ionic compounds.

a) K_3N

c) Li_2O

b) $BaCl_2$

d) Sr_3P_2

B. Polyatomic Ions (Complex Ions)

- Cations or anions composed of a group of atoms with a net positive or negative charge

When compounds containing these ions are dissolved in water, the polyatomic ion stays together as one unit.

- Ex NH_4^+ NO_2^- NO_3^- CO_3^{2-}
Ammonium ion Nitrite ion Nitrate ion Carbonate ion

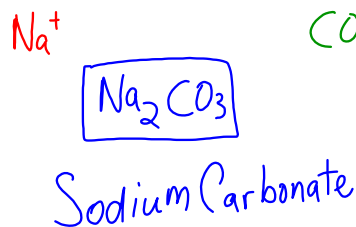
See page 196 for a table of some common polyatomic ions.

Note that rules for naming are the same as those for binary ionic compounds. Just remember that the complex ion remains as one.

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Nov 22-10:13 PM

Ex1: Write the name and chemical formula for the compound formed by sodium and a carbonate ion.



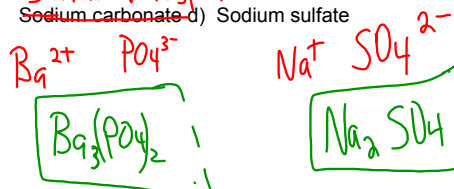
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Ex2: Write the chemical formulas.

a) Ammonium nitrate c) potassium carbonate

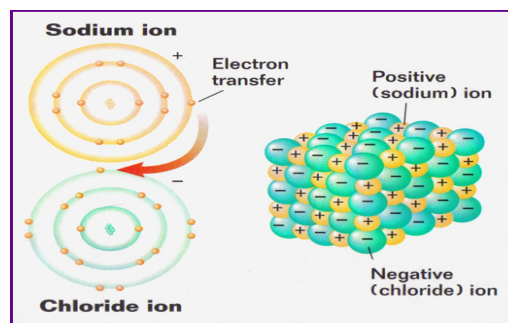
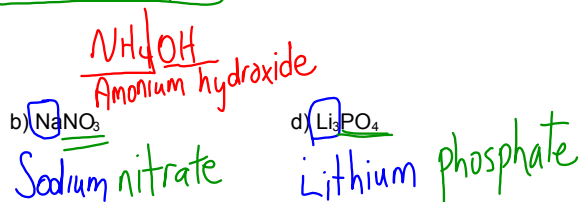
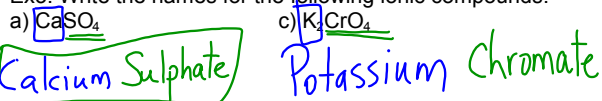


b) ~~Sodium carbonate~~ d) Sodium sulfate



Nov 23-9:06 PM

Ex3: Write the names for the following ionic compounds.



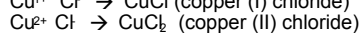
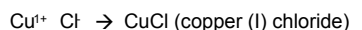
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C. Multivalent Ions

- certain transition metals can form more than one kind of ion, each with a different charge Ex. Fe^{3+} Fe^{2+}
- The more commonly occurring is listed on top, thus Fe^{3+} is more common than Fe^{2+}

Copper for example forms two completely different compounds when with chlorine - one is white (1+), the other is yellow (2+).



Ex 1: What compound is described by FeO_3 ?

Solution: Fe^{2+}

Fe_2O_3

Ex2: Write the chemical formulas.

a) Iron(II)sulphide b) lead(IV)oxide

c) Copper (I) Chloride d) Copper (II) Chloride

Note: The method of naming using Roman Numerals is called the System.

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Nov 23-9:11 PM

Ex3: write the names for the following ionic compounds.

a) NiS

b) MnF_4

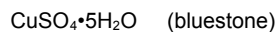
c) CuF

d) Cr_2O_3

D. Hydrated Ionic Compounds

- Water molecules are loosely held within the ionic compound
- Produce water when they decompose upon heating

An example of a hydrated compound is copper (II) sulfate pentahydrate,



This formula indicates that 5 molecules of water are bonded with the ionic crystal for every 1 formula unit of CuSO_4 .

Common prefixes used in naming hydrated compounds are:

1=mono 6=hexa
 2=di 7=hepta
 3=tri 8=octa
 4=tetra 9=nona
 5=penta 10=deca

Dec 3-10:57 AM

Nov 22-10:18 PM

Ex1: Write the chemical formula.

- a) barium hydroxide octahydrate b) Zinc chloride hexahydrate

Ex2: Write the names for the following ionic compounds.

- a) $MgSO_4 \cdot 5H_2O$ b) $FeCl_2 \cdot 4H_2O$

-) Copper(II)sulphate pentahydrate d) lithium hydroxide octahydrate

- c) $Ca(NO_3)_2 \cdot 6H_2O$

- d) $HgNO_3 \cdot H_2O$

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Solubility of an Ionic Compound

Dissociation

< refers to the separation of ions that occurs when an ionic compound dissolves in water.



< the solubility of an ionic compound will determine whether or not it will completely dissociate into ions in solution:

- i) high solubility (aq) will completely dissociate into ions;
- ii) low solubility (s) will not completely dissociate.

Q. Predict which of the following ionic compounds will dissociate and write a dissociation equation.
 $CaSO_4$, NH_4OH , Na_2SO_4 , $MnCO_3$, $Mg(NO_3)_2$

A: Check solubility using table.

SOLUBILITY OF IONIC COMPOUNDS AT SATP - GENERALIZATIONS							
Anion	Cl ⁻ Br ⁻ I ⁻	S ²⁻	OH ⁻	SO ₄ ²⁻	(CO ₃ ²⁻) O ₄ ³⁻ SO ₃ ²⁻	CH ₃ COO ⁻	NO ₃ ⁻
High Solubility (aq)	most	Group 1 NH ₄ ⁺ Group 2	Group 1 NH ₄ ⁺ Sr ²⁺ Ba ²⁺ Tl ⁺	most	Group 1 NH ₄ ⁺	most	all
Low Solubility (s)	Ag ⁺ Pb ²⁺ Tl ⁺ Hg ₂ ²⁺ (Hg ⁺) Cu ⁺	most	most	Ag ⁺ Pb ²⁺ Ca ²⁺ Ba ²⁺ Sr ²⁺ Rb ⁺	most	Ag ⁺	none

All Group 1 compounds, including acids and ammonium compounds, are assumed to have high solubility in water.

$CaSO_4(s)$ - does not completely dissociate
 $NH_4OH(s) \rightarrow NH_4^+(aq) + OH^-(aq)$
 $Na_2SO_4(s) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$
 $MnCO_3(s)$ - does not completely dissociate
 $Mg(NO_3)_2(s) \rightarrow Mg^{2+}(aq) + 2NO_3^-(aq)$

Nov 19-9:37 AM

Nov 19-9:38 AM

General Rules-Summary

Write each ion symbol with charge: simple ions from front of periodic table; complex on back.

Assign the correct subscripts to each ion (subscript indicates the number of the ion preceding it).

Total positive charge = total negative charge.

Switch charges to give subscripts: charge on cation becomes subscript for anion, and vice-versa.

Use lowest whole number ratios.

OR

b) Find lowest common denominator for the charges of the 2 ions. For each ion, multiply the ion charge by a subscript number that will give the common denominator.

3. Write symbol of each ion with subscript. **Do not include ion charges in final formula.**

Note:

For multivalent ions, the Roman numeral = charge on the cation, **not** the subscript.

For hydrates, prefix indicates the number of water molecules present in the ionic compound.

If more than one complex ion is present, place brackets around it, then give subscript.

Sep 13-1:33 PM

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Naming Ionic Compounds**General Rules:****Name each ion**

• **Monatomic:** cation retains metal name, anion name ends in "ide"

• **Polyatomic:** give name from back of periodic table

Multivalent: use Roman numerals to indicate charge (I, II, III, IV, V, VI)

Hydrated: use Latin prefixes to indicate # of water molecules present

1 = mono 2 = di 3 = tri 4 = tetra 5 = penta
6 = hexa 7 = hepta 8 = octa 9 = nona 10 = deca

Examples: Name the following compounds

Ca₃P₂ _____

AlCl₆ _____

Na₂BO₃ _____

(NH₄)₂CO₃ _____

FeO _____

V₃N₆ _____

Sep 13-1:35 PM

Sep 13-1:36 PM

Nov 25-2:34 PM