CHEM 115
Chemical Nomenclature

Lecture 4
Prof. Sevian

1

Announcements

- Test at the beginning of Lab 2 next week
  - You do not need to study for this test. It is a pre-test of your prior understanding of the chemistry you will learn this semester.
  - Students who are not enrolled in lab should go to the first hour of one of the lab sections next week (Mon 1:00PM, Tues 8:30AM or Weds 1:00PM) – if that is not possible, then email me to set up a time next week to take the test (hannah.sevian@umb.edu)
  - If you do not take the pre-test next week, you will get 0 out of 10 points for it. If you take the pre-test, you will get 10 out of 10 points.
  - You will need a pencil, an eraser, and a calculator for the test.
  - The test will be in a classroom: M-1-608. After you take the test, you will go back to the lab and do Lab 2.
- Pre-labs must be done before you get to lab
- How to use OWL

2

Facilitated Study Groups

- Tuesdays 3:20 - 4:20PM
- Thursdays 11:30AM - 12:30PM

FSG will begin next week

Both FSG's will be located in the Chemistry conference room: S-1-89

Today's Lecture Agenda

- Register your clickers
- Ions
- Kinds of compounds
  - Ionic vs. molecular
- How to name simple compounds

Organization of the Periodic Table

Terminology we will use all year

- Period = row across
- Group = column down

  Several common groups
  - Group 1A: Alkali metals
  - Group 2A: Alkaline earth metals
  - Group 7A: Halogens
  - Group 8A: Noble gases
  - Groups B: Transition metals

- Early chemists (Mendeleev, Moseley) organized the Periodic Table according to properties of elements
- There are reasons why the Periodic Table is organized the way it is (stay tuned until chapters 6 and 7)

9

Clicker question

Which element is in period 5 and group 2?

A. Ba
B. Dy
C. N
D. Nb
E. Sr

11

Atoms vs. Ions vs. Molecules vs. Formulas

Everything in nature is neutral, but the + and - charges are not evenly spread out

- Atoms
  - Simplest building block of nature (in chemistry class)
  - They are neutral because they have equal amounts of protons (+) and electrons (-)
  - Their identity is determined by how many protons
  - There are about 100 different kinds (called elements)
  - All the different elements are on the periodic table
- Ions
  - When atoms, or groups of atoms that are connected, either gain electrons (become negative) or lose electrons (become positive)
  - Oppositely charged ions attract
  - Ions must co-exist with oppositely charged ions, together in such a way that the whole system is neutral
  - In the solid state, ions are arranged in crystals (+ and - in different locations)
  - In the liquid state, ions can move (“swim”) around, but the overall + and - charges must total zero charge overall

12

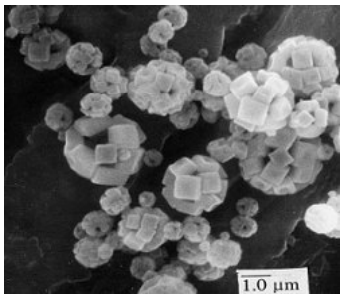
Atoms vs. Ions vs. Molecules vs. Formulas

Everything in nature is neutral, but the + and - charges are not evenly spread out

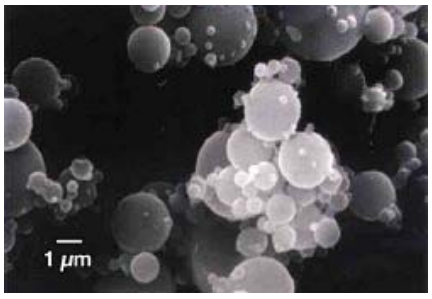
- Molecules
  - Atoms linked together (by chemical bonds)
  - When atoms are in molecules, they are not always perfectly neutral, but for now we will assume they are so that we can contrast molecules with ionic compounds
  - Molecular formula tells how many of each kind of atom are in the molecule
  - Ratio of atoms in a molecule is fixed (for example, every water molecule has 2 hydrogen atoms and 1 oxygen atom, always)
  - The molecular formula tells the ratio of atoms in a molecule
- Formulas
  - The word “formula” usually means it is a ratio of charged ions, not neutral atoms
  - The formula of an ionic compound shows the simplest ratio of ions to get a neutral compound

13

NaCl vs. Sucrose scanning electron microscope (SEM) “pictures”



NaCl (s) dried from a 10% aqueous solution



$C_{12}H_{22}O_{11}$ (s) dried from a 5% aqueous solution

1 μm = 10^{-6} m and 1 nm = 10^{-9} m

For comparison:

Na-Cl internuclear distance = 0.56 nm, therefore in 1 μm fit about 1800 Na-Cl units across

Diameter of a sucrose molecule ≈ 1 nm, therefore in 1 μm fit about 1000 sucrose molecules lengthwise

(Images from http://www.temcoinstruments.com/applications.html)

What you need to understand about bonding for now

Ionic Compounds

- Contain ions
- Held together by electrostatic attraction between + and – ions
- Ionic formula: simply the ratio of ions present in order for the compound to be neutral, cannot separate a unique unit

Molecular Compounds

- Do not contain ions
- Molecules held together by covalent bonds in which electrons from both atoms are attracted to the nuclei of both atoms in a bond
- In a molecular solid, one molecule held to the next by weaker forces of attraction
- Molecular formula: can separate unique molecules

15

What's a Chemical Formula?

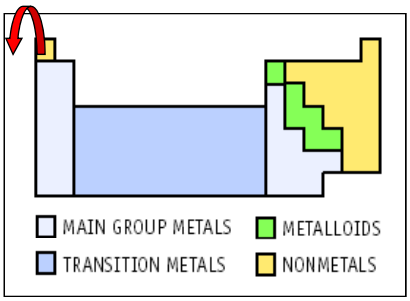
- Whole-number ratio of elements present in a compound
  H_2O CO_2 $Na_2C_2O_4$ $KMnO_4$
- Parentheses indicate groups (ions, functional groups, repeating groups)
  $Mg(C_2H_3O_2)_2$ $C(CH_3)_3Cl$ $CH_3(CH_2)_4CH_3$

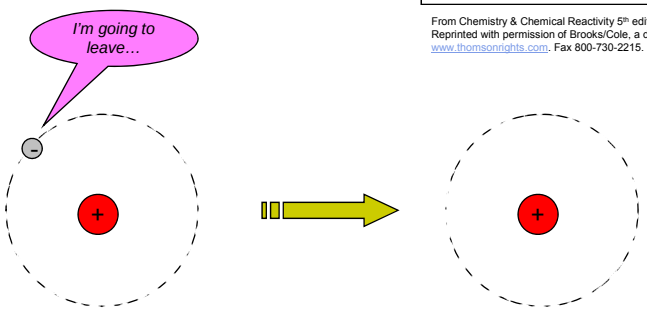
How many C atoms are in a molecule of this compound?

- Numbers follow (they don't precede)
  H_2O H_2O_2

What is an Ion?

1. Hydrogen loses an electron to form H^+



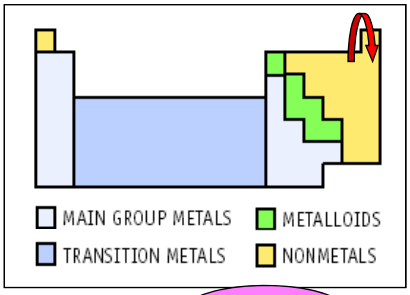


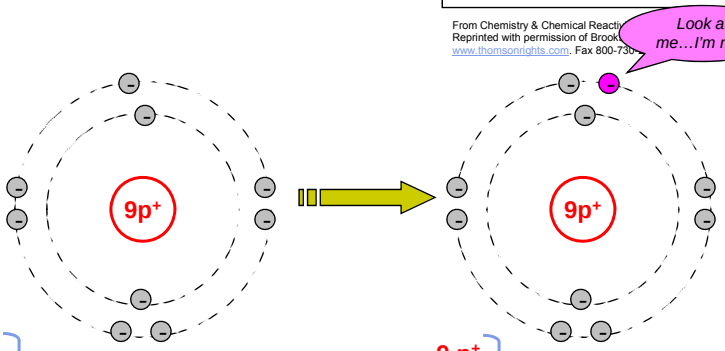
Neutral H atom **H^+ ion**

17

What is an Ion?

2. Nonmetals (except H) gain electrons to form negatively charged ions





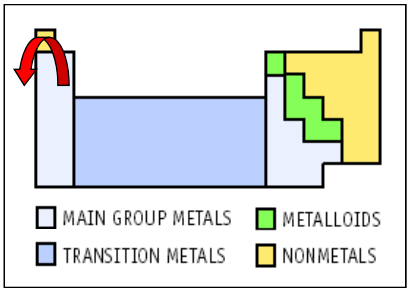
9 p^+
9 e^-
Neutral F atom

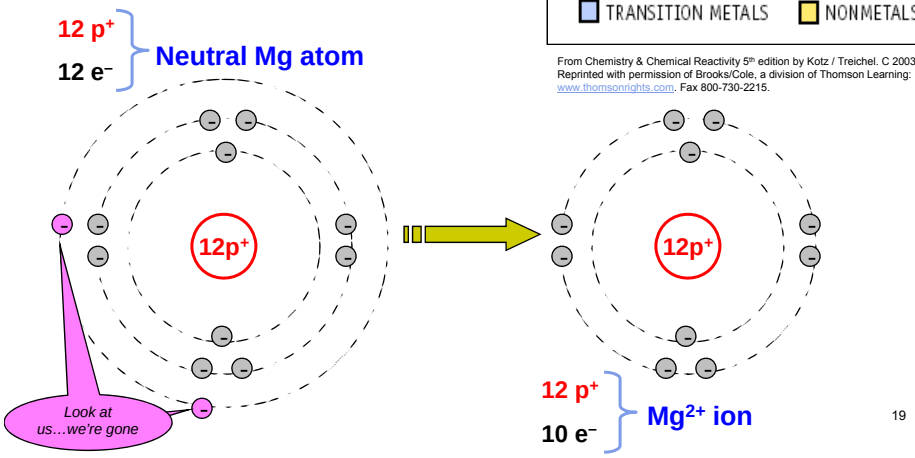
9 p^+
10 e^-
F^- ion

18

What is an Ion?

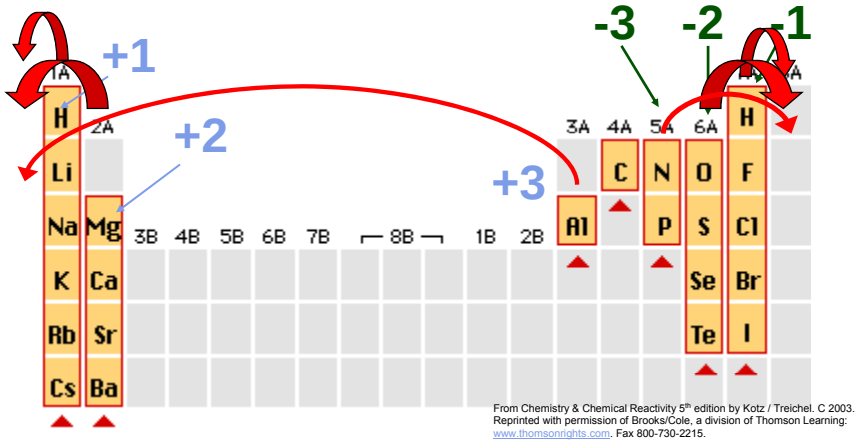
3. Metals lose electrons to form positively charged ions





19

Summary of ion formation: Noble gas envy



Atoms lose or gain electrons to have same number of electrons as nearest Group 8A element

What are the arrows representing in this picture?

What is a "noble gas electron configuration"?

Check your understanding

- When sulfur atoms become ions, what charge are they? What is the symbol of a sulfide ion?

- What is the charge on an aluminum ion? What is its symbol?

Ions and Their Names

When Protons ≠ Electrons

Neutral atom starts with balance of protons & electrons

"noble gas envy" it happens!

Positive Ions

- Metal atoms that lose electrons
- More protons than electrons
- Group A elements always lose electrons to resemble nearest noble gas
- Group B elements can have different quantities of electrons lost
- No name change (but some Group B elements must indicate charge to distinguish)

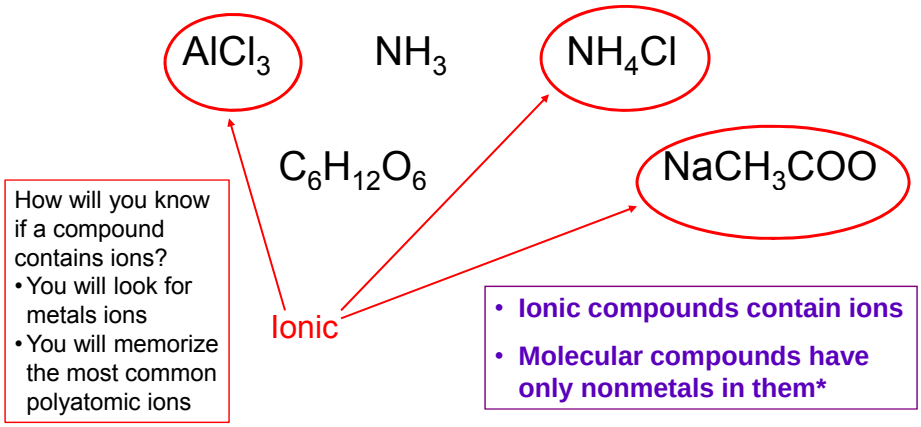
Negative Ions

- Nonmetal atoms that gain electrons
- Fewer protons than electrons
- Group A elements always gain electrons to resemble nearest noble gas
- Suffix of element name changes to "-ide"

22

You need to be able to...

… distinguish between ionic and molecular compounds so that you can name them.



How will you know if a compound contains ions?
- You will look for metals ions
- You will memorize the most common polyatomic ions

- **Ionic compounds contain ions**
- **Molecular compounds have only nonmetals in them***

Names of Common Ions

Find these elements on the Periodic Table and convince yourself why they take the charges they do.

Ion	Name
Cl^-	chloride
Na^+	sodium
Mg^{2+}	magnesium
O^{2-}	oxide
N^{3-}	nitride
Sr^{2+}	strontium
Al^{3+}	aluminum

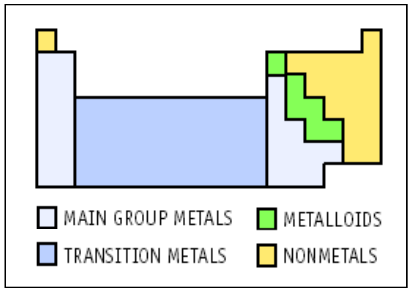
Rule

If nonmetal, change ending to "-ide"

24

Compounds

Two or more different elements that are chemically bonded



Kinds of bonding:

1. Ionic: usually metal ions (+) and nonmetal ions (-) held together by electrostatic attraction
2. Molecular: usually nonmetals held together because proximity of outer electrons on the atoms causes new bonding "orbitals" to exist which have more favorable conditions for electrons
3. Other

25

Ionic vs. Molecular Compounds

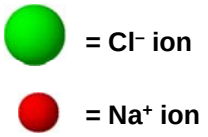
- For simplicity, let's compare some ionic and molecular compounds in the solid state
- Ionic compounds:
  NaCl = table salt, also called sodium chloride
  NH_4Cl = ammonium chloride
- Molecular compounds:
  H_2O (*s*) = ice
  $C_{12}H_{22}O_{11}$ = sucrose

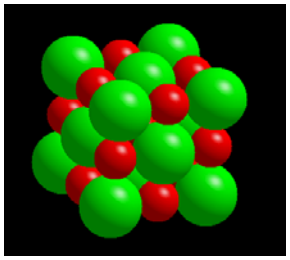
How are they different at the particle level?

26

What do we think an ionic compound looks like at the particle level?

- Regular, repeating lattice structure
- Positive and negative ions held by attractive electrostatic force
- Every + ion surrounded by – ions
- Every – ion surrounded by + ions





Note: Model shows a solid. Ionic bonds are very strong, so it takes a lot of energy to make them molten (liquid). In the liquid state, the ions are free to move about.

NaCl, salt 27

Another Ionic Compound

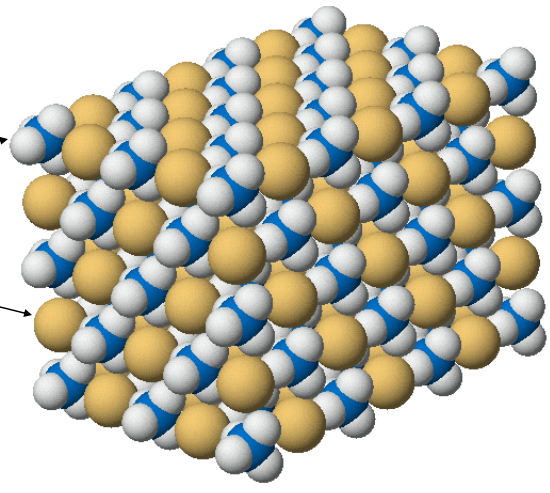
NH_4Cl

made of

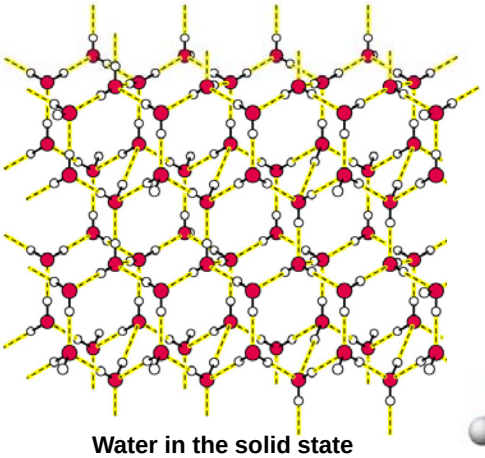
NH_4^+ ions

and

Cl^- ions



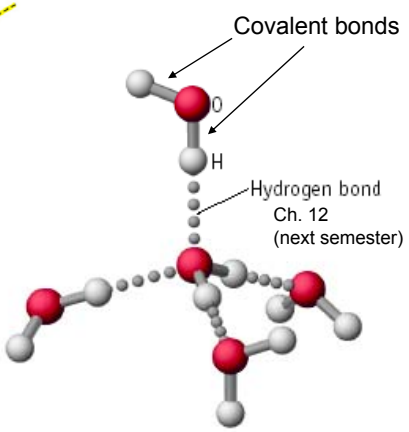
What do we think a molecular compound looks like at the particle level?



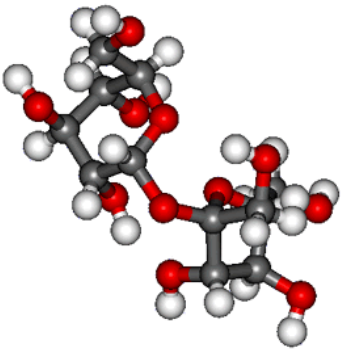
Water in the solid state

Ice crystal structure picture from
http://cwx.prenhall.com/horton/medialib/media_portfolio/text_images/FG02_05.JPG

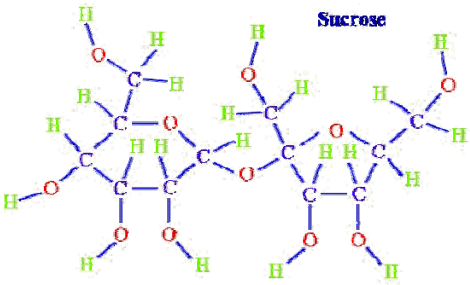
H_2O (*s*)



Another molecular compound



$C_{12}H_{22}O_{11}$ (*s*)



30

What's next?

How do you name compounds?

Naming procedure depends on what kind of compound you have

- Ionic compounds
- Molecular compounds
- Simple acids (some properties common to ionic and other properties like molecular compounds)

31

Common Ions

- Monatomic
  - Group A elements have only one possible charge
  - Group B elements (transition metals) usually have more than one possible charge
- Polyatomic
  - See pp. 62 and 64 for lists of ions you need to memorize (name, formula, charge)

32

Overview of chemical nomenclature (1)

- Given the formula, to figure out the name
  - First figure out if it's ionic, molecular, or an acid, then name according to one of the following rules:

1. Ionic
   - Distinguish the two ions – this will usually involve figuring out their charges
   - First name = positive ion, Last name = negative ion
     - Transition metals need ionic charge given as part of name (you have to say which one since they can take more than one possible charge)
2. Molecular
   - Primarily you will need to know water, ammonia and the first 10 alkanes
   - Otherwise, First name = (prefix)element, Last name = (prefix)element-ide
3. Acid
   - Break down as if it were an ionic compound, H^+ is always the positive ion
   - First name = derived from negative ion, Last name = acid

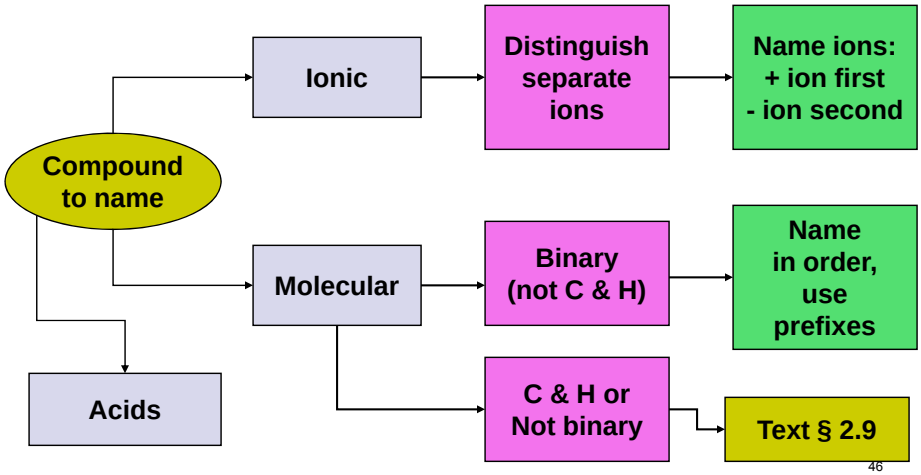
Overview of chemical nomenclature (2)

- Given the name, to figure out the formula
  - First figure out if it's ionic, molecular, or an acid, then determine the formula according to one of the following methods:

1. Ionic
   - First name = positive ion, Last name = negative ion
   - Figure out what the formulas of the ions and their charges are
   - Determine the smallest ratio of ions to make a neutral compound
2. Molecular
   - Primarily you will need to know water, ammonia and the first 10 alkanes
3. Acid
   - First name = derived from negative ion, Last name = acid (means H^+)
   - Figure out the formula and charge on the negative ion is
   - Determine the ratio of H^+ and the negative ion to make a neutral compound

If the compound is neutral, do not write charges in the chemical formula

Naming Rules So Far



46

Common Mistakes in Naming

- Look for ions vs. no ions

NO_3^- vs. NO_3

nitrate ion — nitrogen trioxide

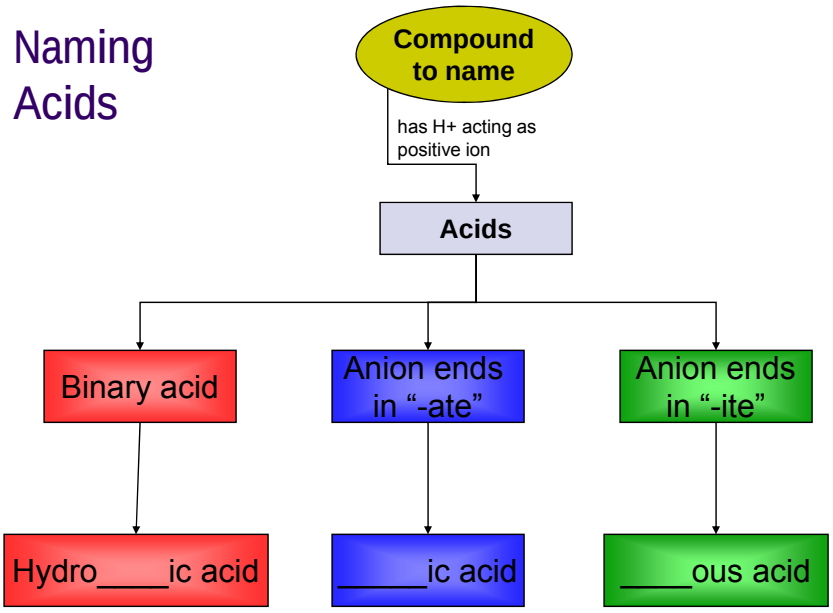
- If ionic compound, regardless of how many total atoms, it has only a first name (+ ion) and a last name (- ion)

$LiHCO_3$ → Li^+ lithium; HCO_3^- hydrogen carbonate

NH_4CH_3COO → NH_4^+ ammonium; CH_3COO^- acetate

47

Naming Acids



Names to Ionic Formulas

Potassium chloride

K^+ Cl^-

+1 -1

What ratio makes a neutral ionic compound?

1:1 ratio ⇒ formula is KCl

Manganese (V) hydroxide

Mn^{5+} OH^-

+5 -1

What ratio makes a neutral ionic compound?

1:5 ratio ⇒

formula is $Mn(OH)_5$

50

Names to Molecular Formulas

Dinitrogen pentoxide

2 of 5 of

N_2O_5

Sulfur hexabromide

1 of 6 of

SBr_6

51

Practice: First determine if it is Ionic, molecular or acid?

- $NaNO_2$
- N_2O_4
- K_3PO_4
- H_2CO_3
- $Al_2(C_2O_4)_3$

- Copper (II) acetate
- Diphosphorus pentoxide
- Acetic acid
- Ammonium nitrate

52