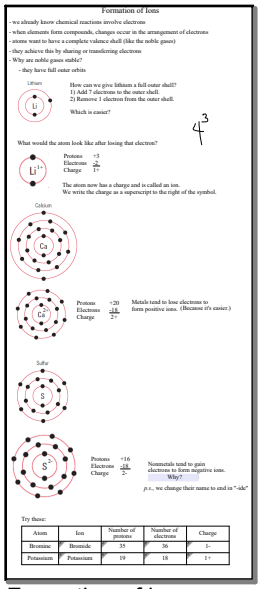

Formation of Ions

- we already know chemical reactions involve electrons
- when elements form compounds, changes occur in the arrangement of electrons
- atoms want to have a complete valence shell (like the noble gases)
- they achieve this by sharing or transferring electrons
- Why are noble gases stable?
  - they have full outer orbits

Lithium

How can we give lithium a full outer shell?
1) Add 7 electrons to the outer shell.
2) Remove 1 electron from the outer shell.

Which is easier?

What would the atom look like after losing that electron?

Protons +3
Electrons 2
Charge 1+

The atom now has a charge and is called an ion.
We write the charge as a superscript to the right of the symbol.

Calcium

Protons +20
Electrons 18
Charge 2+

Metals tend to lose electrons to form positive ions. (Because it's easier.)

Sulfur

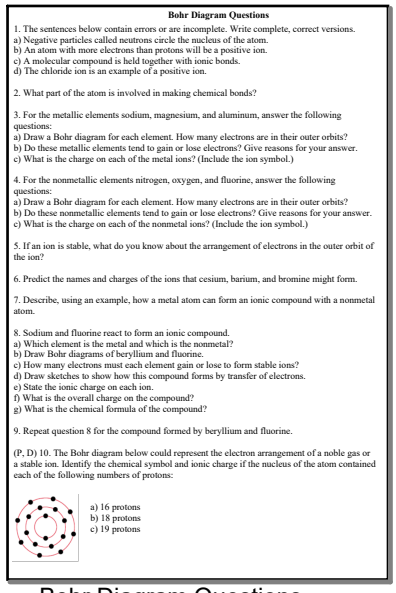
Protons +16
Electrons 18
Charge 2-

Nonmetals tend to gain electrons to form negative ions.
Why?
p.s., we change their name to end in "-ide"

Try these:

Atom	Ion	Number of protons	Number of electrons	Charge
Bromine	Bromide	35	36	1-
Potassium	Potassium	19	18	1+

Formation of ions


Bohr Diagram Questions

1. The sentences below contain errors or are incomplete. Write complete, correct versions.
a) Negative particles called neutrons circle the nucleus of the atom.
b) An atom with more electrons than protons will be a positive ion.
c) A molecular compound is held together with ionic bonds.
d) The chloride ion is an example of a positive ion.

2. What part of the atom is involved in making chemical bonds?

3. For the metallic elements sodium, magnesium, and aluminum, answer the following questions:
a) Draw a Bohr diagram for each element. How many electrons are in their outer orbits?
b) Do these metallic elements tend to gain or lose electrons? Give reasons for your answer.
c) What is the charge on each of the metal ions? (Include the ion symbol.)

4. For the nonmetallic elements nitrogen, oxygen, and fluorine, answer the following questions:
a) Draw a Bohr diagram for each element. How many electrons are in their outer orbits?
b) Do these nonmetallic elements tend to gain or lose electrons? Give reasons for your answer.
c) What is the charge on each of the nonmetal ions? (Include the ion symbol.)

5. If an ion is stable, what do you know about the arrangement of electrons in the outer orbit of the ion?

6. Predict the names and charges of the ions that cesium, barium, and bromine might form.

7. Describe, using an example, how a metal atom can form an ionic compound with a nonmetal atom.

8. Sodium and fluorine react to form an ionic compound.
a) Which element is the metal and which is the nonmetal?
b) Draw Bohr diagrams of beryllium and fluorine.
c) How many electrons must each element gain or lose to form stable ions?
d) Draw sketches to show how this compound forms by transfer of electrons.
e) State the ionic charge on each ion.
f) What is the overall charge on the compound?
g) What is the chemical formula of the compound?

9. Repeat question 8 for the compound formed by beryllium and fluorine.

(P, D) 10. The Bohr diagram below could represent the electron arrangement of a noble gas or a stable ion. Identify the chemical symbol and ionic charge if the nucleus of the atom contained each of the following numbers of protons:

a) 16 protons
b) 18 protons
c) 19 protons

Bohr Diagram Questions

Chemical Compounds

We will learn about two types of compounds:
Ionic – Electrons are *transferred* between metals and nonmetals
Molecular – Electrons are *shared* between nonmetals (These are also called covalent)

Let's try some examples.

Compound	Molecular or ionic	
FeO_2	ionic	
KF	ionic	
CO_2	molecular	(Both nonmetals) What kind of atoms are these?
NaCl	ionic	
H_2O	molecular	(Both nonmetals) What kind of atoms are these?

Types of Compounds

Chemical Formula

A **chemical formula** is a combination of symbols that represent a particular compound.
It shows us
- what elements are in the compound
- the number of each atom present (no subscript means "1")

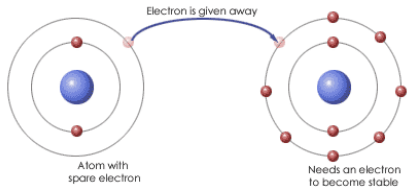
Compound	#	Element	#	Element	
FeO_2	1	iron	2	oxygen	What's the ion name?? oxide
KF	1	potassium	1	fluorine	fluoride
CO_2	1	carbon	2	oxygen	
NaCl	1	sodium	1	chlorine	chloride
H_2O	2	hydrogen	1	oxygen	

Chemical Formula

How do ionic compounds form?

- formed by a metal ion and a nonmetal ion
- the metal atom loses electrons to form a positive ion (called a cation)
- the nonmetal gains electrons to become a negative ion (called an anion)
- the opposite charges cause the two ions to be attracted to each other
- this attraction is called an **ionic bond**
- the result is an electrically neutral compound (charges cancel)

Resulting ionic compound?
Can you name it?



#p? 9
#e? 9

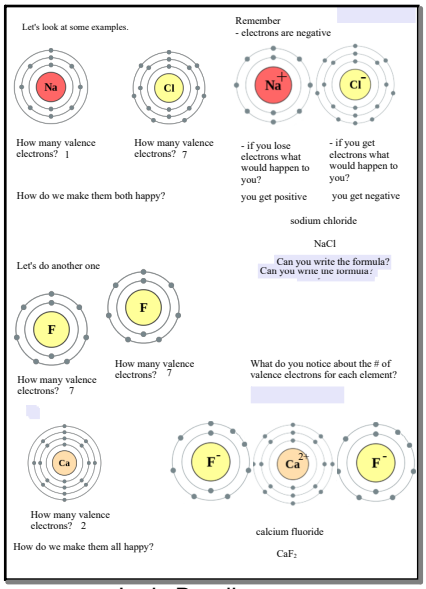
Li
1+

F
1-

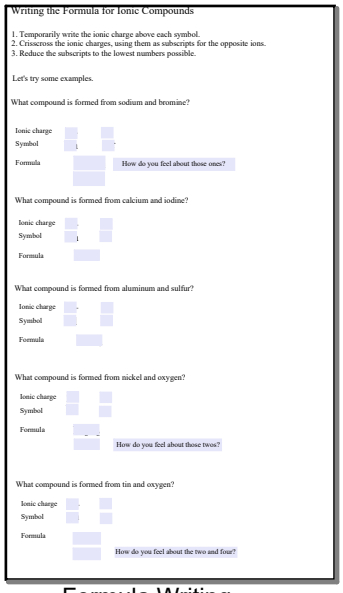
LiF

lithium fluoride

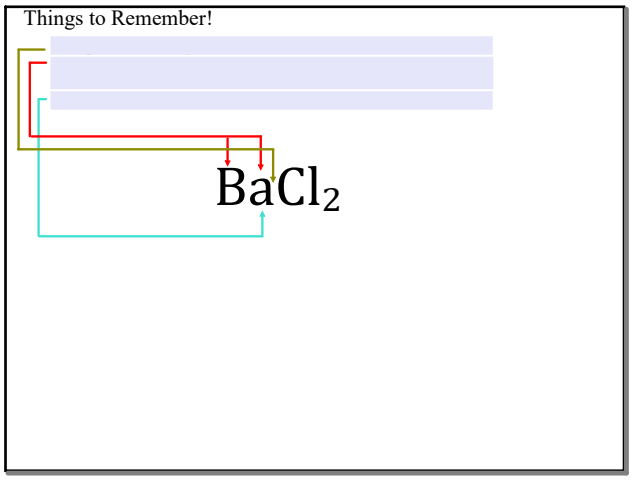
Formation of compounds



Ionic Bonding



Formula Writing



Things to Remember

How do we name these compounds?

Write the name of the metal followed by the name of the nonmetal ending in "ide"

NaCl sodium chloride

CaF_2 calcium fluoride

K_2O potassium oxide

Binary Ionic Compounds

Practice!

Elements	Formula	Name
potassium and oxygen		
sodium and sulfur		
aluminum and iodine		
silver and sulfur		
(P, D) calcium and nitrogen		

Give the name and chemical formula for each of the following:

a) lithium and fluorine

b) sodium and iodine

d) aluminum and nitrogen

c) calcium and bromine

c) sodium and nitrogen

f) beryllium and fluorine

g) magnesium and oxygen

(P, D) h) gallium and sulfur

Practice

Binary Ionic Compounds Questions

1. a) In an ionic compound, what do you know about the sum of the charges on the positive ions compared to the sum of the charges on the negative ions?
b) Calculate the sum of the ionic charges in the compound $BaCl_2$. Show your calculation.

2. Draw a Bohr diagram to show the electron transfer that occurs when magnesium and fluorine form magnesium fluoride.

3. Write the names for the following compounds:
a) KCl
b) Na_3P
c) CaF_2

4. In mining, some minerals are referred to as ferrous. What metallic element is present in these compounds? (Hint: Look at the letters that begin the word.)

(P, D) 5. Calculate the sum of the ionic charges in the compound Al_2O_3. Show your calculation.

Binary Ionic Compounds Questions

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

For each of the following, provide the name or the chemical formula.

Gold	Platinum and Diamond
1. sodium chloride	1. sodium oxide
2. BaO	2. SrO
3. $MgCl_2$	3. AgCl
4. calcium iodide	4. zinc oxide
5. magnesium sulfide	5. aluminum sulfide
6. NaI	6. $BaCl_2$
7. MgO	7. Ag_2O
8. aluminum bromide	8. lithium oxide
9. potassium sulfide	9. calcium sulfide
10. potassium oxide	10. calcium phosphide

Quiz - Binary

(P, D)

Try this one:

Write the formula for the compound formed by iron and iodine.

Ionic charge
Symbol
Formula

Naming compounds of polyvalent metals

Some metals can form more than one kind of ion – they are called **polyvalent metals**.
- write the name of the metal
- add a Roman numeral in parentheses after it to indicate its ionic charge
- use the "ide" ending for the nonmetal

26 Fe^{3+} iron (III)
Fe^{2+} iron (II)

53 I^{1-} iodide

Ionic charge
Symbol FeI_3
Name

Number	Roman numeral
1	
2	
3	
4	
5	

Remember: Roman numerals ONLY show the charge, not the number of ions.

e.g., PbO_2 O 2 x = Pb 1 x ? = What's the "?" ? =

Name it

Try this one: Fe_3N_2 Fe 3 x = ? = N 2 x =

Name it

Polyvalent Ionic Compounds

Polyvalent Ionic Compounds Practice (P, D)

More practice.
1. Write the formula for each of the following compounds:
a) copper(I) bromide
b) copper(II) bromide
c) iron(II) sulfide

2. Write the name for each of the following compounds:
a) $SnCl_2$
b) $SnCl_4$
c) $PbBr_2$

3. Write the formula and name of the compound formed by each of the following combinations of ions.
a) Fe^{3+} and O^{2-}
b) Mn^{2+} and F^-
c) Cu^+ and S^{2-}

Practice

(P, D)

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

For each of the following, provide the name or the chemical formula.

1. nickel(II) bromide
2. Ti_2S_3
3. tin(II) chloride
4. nickel(III) bromide
5. CoN
6. $CoBr_2$
7. TiS_2
8. iron(III) sulfide
9. PbI_2
10. tin(IV) oxide
11. lead(IV) flouride
12. SbN

Quiz - Polyvalent

(P, D)

Polyatomic ion: atoms that tend to stay together and carry an overall ionic charge (*e.g.*, Nitrate ion: NO_3^-).

TABLE OF POLYATOMIC IONS

acetate	CH_3COO^-	dihydrogen phosphate	$H_2PO_4^-$	oxalate	$C_2O_4^{2-}$
arsenate	AsO_4^{3-}	hydrogen carbonate	HCO_3^-	perchlorate	ClO_4^-
arsenite	AsO_3^{3-}	hydrogen oxalate	$HC_2O_4^-$	periodate	IO_4^-
benzoate	$C_6H_5COO^-$	hydrogen sulfate	HSO_4^-	permanganate	MnO_4^-
borate	BO_3^{3-}	hydrogen sulfide	HS^-	peroxide	O_2^{2-}
bromate	BrO_3^-	hydrogen sulfite	HSO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	hydroxide	OH^-	pyrophosphate	$P_2O_7^{4-}$
chlorate	ClO_3^-	hypochlorite	ClO^-	sulfate	SO_4^{2-}
chloride	Cl^-	iodate	IO_3^-	sulfite	SO_3^{2-}
chlorite	ClO_2^-	monohydrogen phosphate	HPO_4^{2-}	thiocyanate	SCN^-
chromate	CrO_4^{2-}	nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$
cyanate	CNO^-	nitrite	NO_2^-	POSITIVE POLYATOMIC IONS	
cyanide	CN^-	orthosilicate	SiO_4^{4-}	ammonium	NH_4^+
dichromate	$Cr_2O_7^{2-}$			hydronium	H_3O^+

Polyatomic Ionic Compounds

Naming Compounds of Polyatomic Ions (P, D)

Ions that contain more than one atom are called polyatomic ions.

- write the symbols for the metal and the polyatomic ion
- write the ionic charges above the symbols and crisscross them
- write the name of the metal first, then the polyatomic ion

Ionic charge
Symbol Na SO_4
Formula
How do you feel about the 2 and 4?
Name

Ionic charge
Symbol Ba NO_3
How do we crisscross with a polyatomic?
Formula
Name

Try these:

a) $Fe(NO_3)_3$

b) $Pb(SO_4)_2$

c) K_2CO_3

d) potassium hydroxide
K OH

e) lead(IV) carbonate
Pb CO_3
How do you feel about the 2 and 4?

Polyatomic Ionic Compounds

(P, D)

1. Write the formulas for the following compounds:
(a) sodium phosphate
(b) calcium sulfate
(c) potassium chlorate
(d) aluminum hydroxide
(e) beryllium nitrate
(f) magnesium hydrogen carbonate
(g) nickel(II) carbonate

2. Write the names for the following compounds:
a) K_2CO_3
b) Na_2SO_4
c) $Al(HCO_3)_3$
d) $AgNO_3$

Practice

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

For each of the following, provide the name or the chemical formula.

1. barium perchlorate
2. potassium permanganate
3. $Cu(NO_3)_2$
4. magnesium phosphate
5. aluminum borate
6. $Ba(ClO_4)_2$
7. iron(II) nitrate
8. mercury(II) carbonate
9. zinc nitrate
10. $ZnCO_3$

Bonus (odd): ammonium citrate

Bonus (even): hydronium tripolyphosphate

Quiz - Polyatomic

Testing for Ions

1. Imagine you're about to take a drink from your water bottle. What kinds of substances might be present in the water?

2. People often say that water from a different area has a different taste. Suggest an explanation for this observation.

Drinking water actually contains many different substances. Some are added deliberately during the process of water purification.

3. Name a substance that might be added deliberately.

Many substances in water occur naturally. As rainwater passes through the ground, minerals dissolve into the water. These minerals are ionic compounds that may contain ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), iron (Fe^{2+}), chloride (Cl^-), nitrate (NO^{3-}), or sulfate (SO_4^{2-}).

An important aspect of water quality monitoring involves detecting the presence of dissolved ions in a water sample. One method of detecting these ions is to use chemical tests. Such tests can also be used to identify unknown ions. A **positive test** for a substance is one that clearly indicates the substance is present. A positive test for a dissolved ion may produce an insoluble precipitate or it may produce a coloured product.

Aztech Laboratory Inc in Quispamsis does water quality testing. Imagine they have recieved a water sample from KVHS and have been asked to test it for the presence of chloride ions (Cl^-), sulfate ions (SO_4^{2-}), and iron ions (Fe^{2+}). Table 1 summarizes what happens when the test reagents are added to a sample containing different ions.

The lab results are shown in Table 2

Table 1: Interpreting water test results

Test for	Test reagent	Results
Chloride ion	Silver nitrate	White precipitate
Sulfate ion	Barium chloride	White precipitate
Iron (III) ion	Potassium thiocyanate	Red color

Table 2: Results of water tests performed by Aztech

Test reagent	Precipitate formed	Solution Color change
silver nitrate	white	none
barium chloride	white	none
potassium thiocyanate	none	red

4. a) Explain what is meant by a positive test for an ion.
b) Describe two types of changes that demonstrate a positive test.

5. Why do you think chemical tests, similar to the tests used in this investigation, are called qualitative analyses?

6. Describe how this type of test could distinguish between a sample that contains a large amount of an ion and one that contains less of the ion.

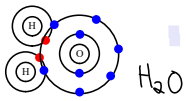
*D7. If a silver nitrate solution is added to a potassium chloride solution and a precipitate forms, what are the names and formulas of the possible products?

*D8. Write chemical formulas for the following substances:
a) silver nitrate
b) barium chloride
c) sodium sulfate
d) iron(III) nitrate

Quiz - Testing for Ions

Molecular Compounds

- most common compounds do not contain ions
- they contain *neutral* groups of atoms called **molecules**.
- a molecule (or molecular compound is made of nonmetals that are *sharing electrons*)
- the shared electrons form a **covalent bond** (these compounds can also be called covalent)



H_2O

How many electrons does H want overall? 2

How many electrons does H need? 1 more

How many electrons does O want overall? 8

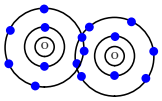
How many electrons does O need? 2

Look at these examples...

How many electrons does each need? 1 more

How can they be happy?

Chemical formula? H_2



How many electrons does each need? 2 more

How can they be happy?

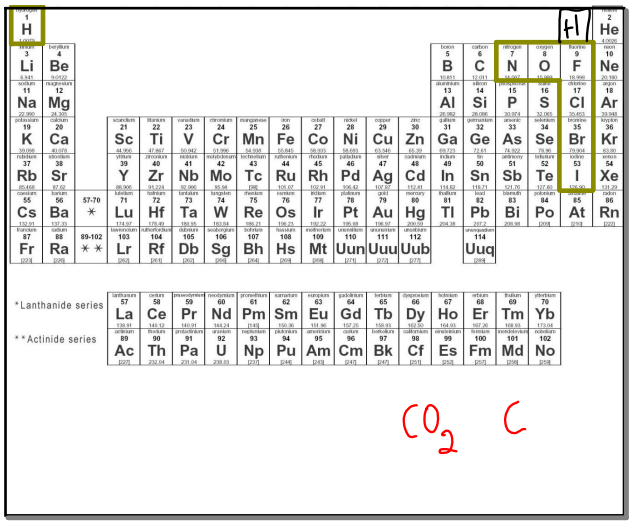
Chemical formula? O_2

Diatomic Molecules are elements that exist naturally as molecules made of two atoms.

- H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

Geez! How can I remember those?
Start at 7, make a 7, and don't forget the hat!

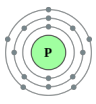
Molecular Compounds



CO_2 C

Diatomics

The **combining capacity** (or **valency**) is the number of covalent bonds that a nonmetal needs to form a stable molecule.



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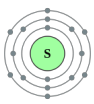

2

How can you know the combining capacity of an element?
- it's the number of groups away from a noble gas.

Element	Combining capacity
C	4
F	1
Cl	1
S	2
O	2

e.g., What compound is formed from carbon and hydrogen?

Step 1: Write the left-most element first then the right

C H

Step 2: Write the combining capacities above the element symbols

4 1
C H

Step 3: Crisscross the combining capacities to get subscripts

C_1H_4

Step 4: Remove any "1" subscripts - they're not needed

CH_4

Molecular Formula

Prefixes indicate the number of atoms present.

If there is only one atom of the first element listed, the prefix MONO is not needed.

Number	Prefix
1	mon(o)
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

Let's try some examples.

N_2O_3 2 N = di, 3 O = tri — dinitrogen trioxide (like in ionic)

SiO_2 1 Si = mono, 2 O = di — silicon dioxide - no mono for the first element

CO 1 C = mono, 1 O = mono — carbon monoxide - no mono for the first element

- oxygen starts with "o" so mon instead of mono

Naming Molecules

Molecular Compounds Questions

1. How can you tell the difference between ionic compounds and molecular compounds?

2. a) What kinds of atoms form molecular compounds?
b) How do the atoms in molecular compounds form stable electron configurations?
c) What type of bond holds atoms together in molecules?

3. What is the relationship between combining capacity of an atom and the number of electrons it needs to share to be like the nearest noble gas?

4. a) How many valence electrons are there in a fluorine atom?
b) How many electrons does a fluorine atom need to share to become stable?
c) Draw a sketch to show how two fluorine atoms could form a stable molecule.

5. Name the following compounds:
a) CBr_4
b) NI_3
c) OF_2
d) $SiCl_4$

6. Write chemical formulas for and name the molecular compounds forms by the following pairs of elements:
a) silicon and oxygen
b) nitrogen and hydrogen
c) phosphorus and chlorine
d) sulfur and bromine
e) oxygen and fluorine
f) carbon and chlorine

7. Why can't two metal atoms form a covalent bond?

Questions - Molecular

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

For each of the following, provide the name or the chemical formula.

1. iodine
2. SO_3
3. silicon monocarbide
4. dinitrogen pentaoxide
5. diphosphorus pentasulfide
6. NO
7. dihydrogen monoxide
8. P_4O_8
9. N_2O_3
10. oxygen dibromide
11. CF_4
12. sulfur hexafluoride
13. silicon tetrahydride
14. F_2

Quiz

If you're sitting on the left, answer the odd-numbered questions. If you're sitting on the right, answer the even-numbered questions.

For each of the following, provide the name or the chemical formula.

(G)
1. sulfur dioxide
2. barium selenide
3. CCl_4
4. AlN
5. lithium nitride
6. disulfur hexafluoride
7. CaS
8. N_2O_3
9. silver sulfide
10. potassium nitride

(P, D)
1. barium oxide
2. calcium chloride
3. magnesium hydroxide
4. silver sulfate
5. copper(I) carbonate
6. titanium(IV) oxide
7. NF_3
8. CCl_4
9. dinitrogen trioxide
10. tetranitrogen hexasulfide
11. $FeCl_3$
12. Fe_2O_3
13. $CaCO_3$
14. KNO_3

Bonus (left): $Cr_2(CO_3)_3$
Bonus (right): $Fe(NO_3)_2$

Quiz All Sorts