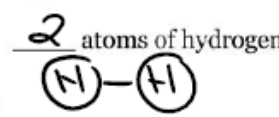
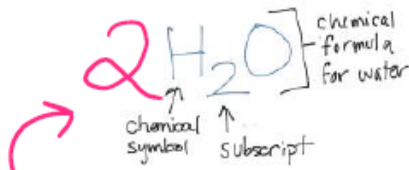


PART 9: MOLECULES & CHEMICAL FORMULA:

- **Molecules** are particles made up from 2 or more atoms
 - Examples: O_2 (2x oxygen) or H_2O (2-hydrogen + 1-ox.)
- Atoms in compounds are **held together** by **chemical bonds** "glue"/connections between the atoms
 - They can be the **same kind of atoms**: $H-H$ H_2 } Both Pure Substances
 - They can be **different kinds of atoms**: $Na-Cl$ $NaCl$ } compounds.
- There are two different kinds of compounds in this unit: covalent compound & ionic compounds

Counting Atoms in Molecules

- When writing chemical formulas, we use: subscripts & coefficients
- **Subscript:**
 - A subscript is a **number** that is **dropped down** after a **element symbol**.
 - They tell you **how many** of that **atom** are in the compound.
 - Examples: H_2 ← subscript 2 atoms of hydrogen



$C_6H_{12}O_6$ = glucose "sugar"

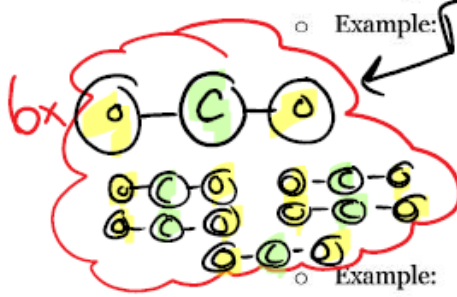
6 atoms of carbon

12 atoms of hydrogen

6 atoms of oxygen

24 atoms in total (whole compound)

- **Coefficient:**
 - A coefficient is a **big number** **in front** of an atom or compound.
 - It tells you how **many** of that **atom or comp.** is involved in a **chemical reaction**.
 - Example: $6CO_2$ Coefficient: 6 Subscript: 2



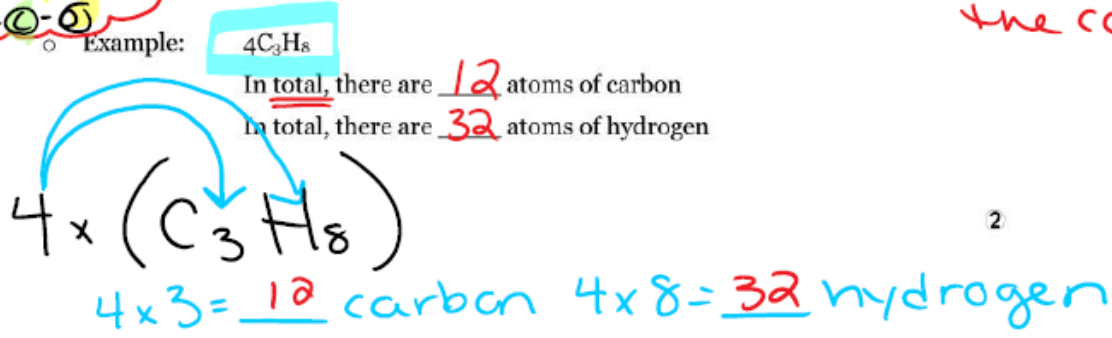
In one molecule, there are 1 atoms of **carbon**

In one molecule, there are 2 atoms of **oxygen**

In total, there are 6 atoms of **carbon**

In total, there are 12 atoms of **oxygen**

$6 \times$ the number of atoms in the compound.



Using Brackets

- Brackets separate out smaller molecules within a larger compound thereby allowing subscripts to be used just within the bracketed area.

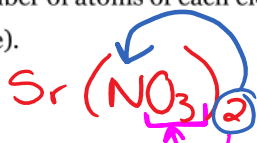
Example: $\text{Sr}(\text{NO}_3)_2$

Strontium + nitrate $\text{Sr}^{2+} + \text{NO}_3^-$

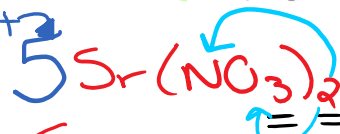
- In words: $\text{Sr}(\text{NO}_3)_2$ is the equivalent of: Three oxygen atoms attached to each nitrogen atom and two of these structures are attached to one strontium ion.

Calculate the number of atoms of each element in ONE molecule and in FIVE molecules of $\text{Sr}(\text{NO}_3)_2$ (strontium nitrate).

One molecule



Five molecules



<u>1</u>	Strontium	→	Sr	$5 \times \underline{1} = \underline{5}$
<u>2</u>	Nitrogen	→	N	$5 \times \underline{2} = \underline{10}$
$2 \times 3 = \underline{6}$	Oxygen	→	O	$5 \times \underline{6} = \underline{30}$

Total = 9 atoms

Total = 45 atoms in 5 $\text{Sr}(\text{NO}_3)_2$

↑ subscript.

PRACTICE

Count the total number of atoms in each of the following molecules/ions.

- | | | | |
|---------------------------------------|-----------|------------------------------------|-----------|
| 1. BaS | <u>2</u> | 2. N ₂ O ₄ | <u>6</u> |
| 3. CN ⁻ | <u>2</u> | 4. ClO ₂ ⁻ | <u>3</u> |
| 5. NaNO ₃ | <u>5</u> | 6. CH ₄ | <u>5</u> |
| 7. SnCl ₂ | <u>3</u> | 8. Na ₂ Se | <u>3</u> |
| 9. NH ₃ | <u>4</u> | 10. NO ₃ ⁻ | <u>4</u> |
| 11. PO ₄ ³⁻ | <u>5</u> | 12. OCl ₂ | <u>3</u> |
| 13. PbO ₂ | <u>3</u> | 14. FeCl ₃ | <u>4</u> |
| 15. SO ₂ | <u>3</u> | 16. S ₂ F ₁₀ | <u>12</u> |
| 17. OH ⁻ | <u>2</u> | 18. K ₃ P | <u>4</u> |
| 19. (NH ₄) ₂ S | <u>11</u> | 20. NO ₃ | <u>4</u> |
| 21. NO | <u>2</u> | 22. NH ₄ ⁺ | <u>5</u> |
| 23. BeBr ₂ | <u>3</u> | 24. PdI ₄ | <u>5</u> |

Homework

ASSIGNMENT #4: Counting Atoms in Molecules

This assignment is to be completed below in the space provided.

Complete the chart below by filling in the missing information. The first formula has been completed as an example.

Formula	Number of elements	Names of the elements	Number of atoms of each element	Total number of atoms in molecule
MgO	2	magnesium oxygen	1 1	2
SO ₂	2	Sulphur oxygen	1 2	3
NH ₃	2	nitrogen hydrogen	1 3	4
H ₂ O ₂	2	hydrogen oxygen	2 2	4
Fe ₂ O ₃	2	iron oxygen	2 3	5
H ₂ CO ₃	3	hydrogen carbon oxygen	2 1 3	6
(NH ₄) ₃ P	3	nitrogen hydrogen phosphorus	3 12 1	16
Ca(OH) ₂	3	calcium oxygen hydrogen	1 2 2	5
MgSO ₄	3	magnesium sulphur oxygen	1 1 4	6

PARTH: TYPES OF COMPOUNDS

FORMING COMPOUNDS

When two atoms move close together, their **valence electrons interact**.

A **chemical bond** forms between the atoms if the new arrangement of atoms and electrons is stable.

A compound forms when electrons are **shared** or "**stolen**" between two or more different elements in regular, repeating proportions.

↳ "gained" or "lost" (ions)

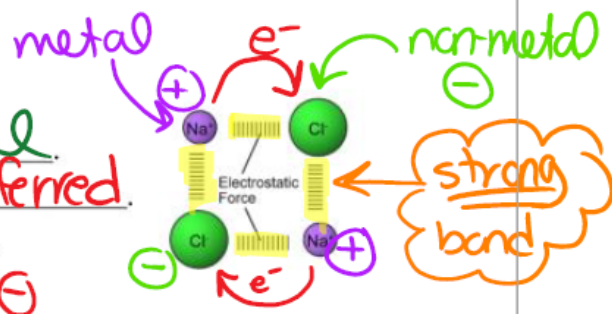
When an atom forms a compound, it may acquire a **valence shell like its closest noble gas** in one of three ways:

1. Atoms of **metals** may **give e^-** to other atoms, forming **cations \oplus**
 2. Atoms of **non-metals** may **gain** electrons from other atoms, forming an **anion \ominus**
 3. Atoms may **share** electrons. (covalent bonding)
- } ionic compounds

TYPES OF BONDS

Ionic Compounds

- Ionic compounds contain only **2** parts – a **metal** and a **NON-metal**.
- Ionic compounds form when electrons are "stolen" or **transferred**.
- An **electrostatic FORCE** holds ionic compounds together.



↳ \oplus attracted to a \ominus

Covalent Compounds

- Covalent compounds contain only **1** parts – a **non-metal** and a **NON-metal**.
- Covalent compounds **share** electrons.



PRACTICE Ionic or Covalent Compound?

For each of the following questions, determine whether the compound is ionic or covalent and write an I (ionic) or C (covalent) on the line beside.

- | | | | | |
|-----------------------------|-----------------|---------------------------|----------|-----------------|
| 1) Na_2CO_3 | <u>ionic</u> | 6) GaCl_3 | <u>I</u> | metal |
| 2) P_2O_5 | <u>covalent</u> | 7) CoBr_2 | <u>I</u> | nonmetal |
| 3) NH_3 | <u>C</u> | 8) B_2H_4 | <u>C</u> | |
| 4) FeSO_4 | <u>I</u> | 9) CO | <u>C</u> | |
| 5) SiO_2 | <u>C</u> | 10) P_4 | <u>C</u> | |

all non-metal atoms, (must be covalent)

CHEMICAL BONDING



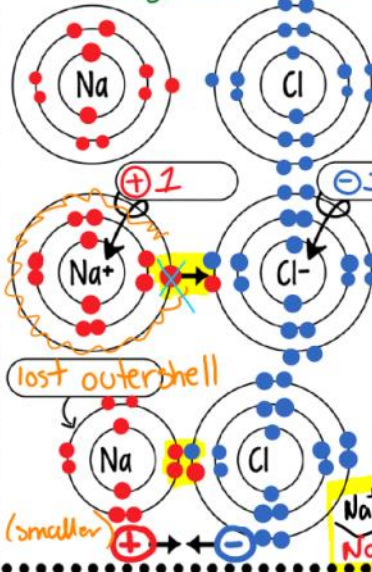
WHY DO BONDS FORM?

Atoms bond because they become more **stable** when they have **full** outer **shell**. Donating, **gaining**, or sharing **electrons** allows them to achieve **stable valence shell**. The **Octet Rule**: 8 electrons in the **outer shell**. (Full)

IONIC

Ionic bonding occurs when a **metal** atom donates one or more **electrons** to a **non-metal** atom. The **metal** becomes more **positive (cation)** and the **non-metal** becomes more **negative (anion)**.

WHAT IS AN ION?
Atoms are normally **electrically neutral** & same number of **protons** & **neutrons**. An **ion** is an atom that has **lost** or **gained** an electron.



A sodium atom has **1** outer **electron**. Chlorine has **7**.

atoms are **not** happy!

sodium donates its outer electron to the **chlorine** atom.

Both are **happy** (Full valence)

Now the atoms have **opposite** charges and **attract**

IONIC BOND

Nitrogen has space for **3** more e^- . Each hydrogen atom **share** its **1 e^- .**

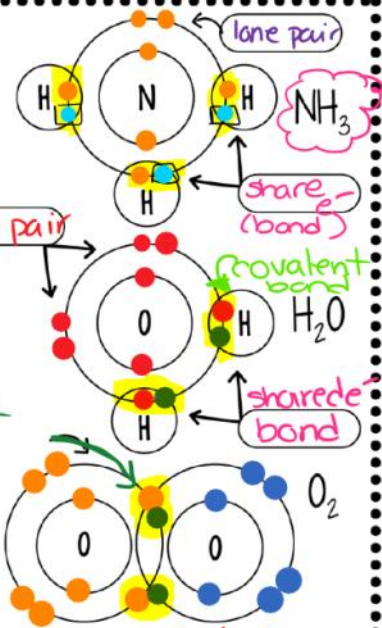
Lone pairs **repel** the bond e^- ... give shape

Oxygen has space for **2** more e^- . Each hydrogen atom **share** its **1** e^- .

2 covalent bonds

Oxygen has **6** outer electrons. In O_2 , each atom **share** 2 electrons.

Covalent bonding occurs when atoms **share** pairs of **electrons** instead of giving and receiving. The **pair** is included in the **outer shell** of **both** atoms. Covalent bonding occurs between atoms of **NON-metals**.



COVALENT

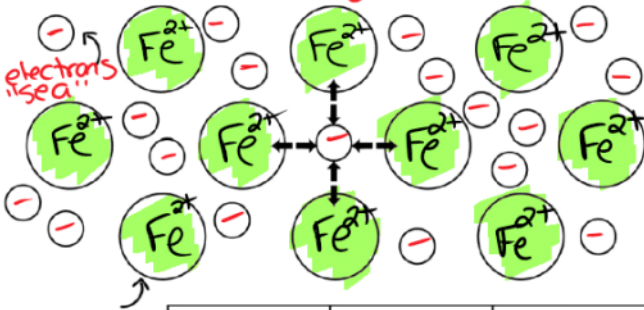
CHEMICAL BONDING



WHAT IS THE DIFFERENCE BETWEEN A COMPOUND AND A MOLECULE? → NaCl
 A compound is two or more **different** elements bonded together. A **molecule** is two or more **atoms** bonded together (they don't have to be **different**). **NaCl** is a molecule but not a compound.

METALLIC

Metallic bonds occur when atoms of **metals** give up **valence** electrons, forming an electron "**sea**". The **positive** charged atoms are "**bonded**" through their **attraction** to the **negative** charged electrons.



	IONIC	COVALENT	METALLIC
Electrons	gain/lost	shared	e ⁻ "sea"
Bond	metal + non-metal	non-metal + non-metal	metal + metal
State	solid	liquid, gas	solid
Conductivity	only when dissolved in H ₂ O	NO	yes
Melting Point	high	Low	(most) High
Examples	salt, NaCl	H₂O, O₂	Fe, Al, Cu

You try:

← HW

What is the most important factor affecting how atoms form chemical bonds? Why?

Valence electrons because they determine how many electrons the atom wants to share, take, or giveaway.

Atoms of which elements tend to gain electrons? Atoms of which elements tend to lose electrons?

Non-metals tend to gain electrons and metals tend to lose electrons.

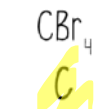
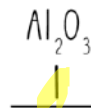
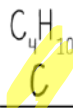
When a Cl atom gains an electron, it gets a charge of **-** and is known as a(n) **anion**.

It gains a charge of **-1** and is known as an "anion".

What is the Octet Rule?

Elements tend to combine in such a way that each atom has 8 electrons in its outer shell - 2 for hydrogen.

Identify each of the following as ionic (I) or covalent (C).



Homework

ASSIGNMENT #5: Reading about Compounds pg 22-23 Comparing Ionic + Covalent Compounds pg 24 & "Compounds Review" pg 25

This assignment is to be completed below in the space provided.

READING ABOUT COMPOUNDS

Complete the following reading about types of compounds and their properties.

Be sure to "Mark the Text" and highlight KEY DEFINITIONS as you read along.

ALSO, answer the "Reading Check" questions in the side margin as you go! ✓



Mark the Text

Identify Definitions

Highlight the definition of each word that appears in bold type.



Reading Check

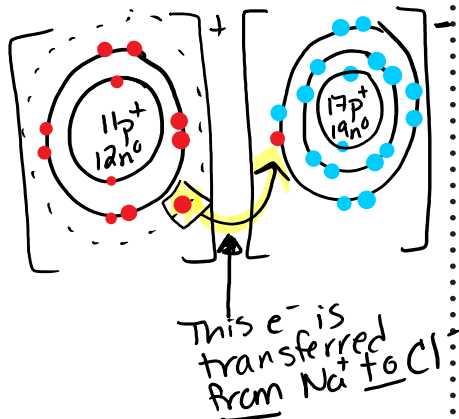
1. When is an ionic compound formed?

when atoms gain or lose electrons



Reading Check

2. Draw a Bohr Diagram of an Na^+ ion and a Cl^- ion. Circle the electron that Sodium loses and draw an arrow to show how that electron is given to chlorine.



How do compounds form?

Recall that an element is a pure substance that is made up of one type of atom. A **compound** is a pure substance that is made up of two or more types of atoms that are joined together due to a chemical change. Water, sugar, and table salt are three examples of compounds.

Atoms are held together in compounds by chemical bonds. These chemical bonds are created by attractive forces between atoms. Chemical bonds are formed when atoms gain or lose electrons, or when they share electrons. Recall that an atom is electrically neutral. When an atom loses electrons it becomes positively charged. When an atom gains electrons it becomes negatively charged.

What are ionic compounds?

If atoms gain electrons from other atoms or lose electrons to other atoms, they form **ionic compounds**. Ionic compounds usually form between metals and non-metals. Why? The atoms in metals tend to lose electrons. So metals have a positive charge when they form ions. The atoms in non-metals tend to gain electrons. So non-metals have a negative charge when they form ions. ✓

How do ionic compounds form?

When atoms of a metal come near atoms of a non-metal, they may join together to form an **ionic compound**. Electrons from the metal atoms are transferred to the non-metal atoms to create oppositely charged ions that attract each other. For instance, think about what happens when a sodium atom (metal) comes near a chlorine atom (non-metal). The sodium atom loses an electron to form a positive ion, and the chlorine atom gains an electron to form a negative ion. The two oppositely-charged ions are attracted to each other. ✓

Ionic compounds are made up of charged particles (ions), but the positive charges and the negative charges balance, so ionic compounds are neutral.

A repeating pattern of positive and negative ions in a compound is called an **ionic lattice**, sometimes also called a crystalline lattice.

How do covalent compounds form?

Sometimes atoms share electrons instead of ions. When atoms share electrons, they form covalent compounds. Covalent compounds form when non-metal atoms bond together by sharing their electrons. Since the electrons are shared, the particles that make up covalent compounds are neutral. They do not have a charge. A neutral particle that is made up of atoms that are joined together by covalent bonds is called a molecule. A water molecule is a covalent compound. Its molecules are made of hydrogen and oxygen. Carbon dioxide gas is also a covalent compound. Its molecules are made of carbon and oxygen. ✓

What is a polyatomic ion?

Some ions contain more than one atom. For example, the nitrate ion (NO_3^-) contains nitrogen and oxygen. The carbonate ion (CO_3^{2-}) contains carbon and oxygen. In these many-atom ions, the atoms are held together with covalent bonds. But the many-atom unit has a charge, so it is considered an ion. An ion that is made up of two or more atoms that are held together with covalent bonds is called a polyatomic ion.

✓ Reading Check

3. When is a covalent compound formed?

when non-metal atoms bond by sharing electrons.



Use the terms in the READING to fill in the blanks.

1. A pure substance that is made up of one type of atom is called a(n) element.
2. A pure substance that is made up of two or more types of atoms that are joined together due to a chemical change is called a(n) compound.
3. Atoms in a molecule and ions in an ionic lattice are held together by chemical bonds.
4. Chemical bonds are formed when atoms gain or lose electrons or when they share electrons.
5. When an atom loses electrons it becomes positively ⊕ charged. When an atom gains electrons it becomes negatively ⊖ charged.
6. Metals and non-metals may form ionic compounds.
7. The atoms in non-metals tend to gain electrons.
8. A(n) ionic lattice is a repeating pattern of positive and negative ions.
9. Covalent compounds form when non-metal atoms bond together by sharing their electrons.
10. A neutral particle that is made up of atoms that are joined together by covalent bonds is called a(n) molecule.
11. A(n) polyatomic ion is an ion that is made up of two or more atoms that are held together with covalent bonds.

Comparing ionic and covalent compounds

Use the chart to help you compare ionic compounds and covalent compounds. On the left side, place the letters of the statements that are only true of ionic compounds. On the right side, place the letters of the statements that are only true of covalent compounds. In the middle, place the letters of the statements that are true of both compounds.

- A. atoms gain or lose electrons to form ions
- B. pure substance made up of two or more kinds of elements
- C. compound is made of a positive ion and a negative ion
- D. atoms join by sharing electrons
- E. atoms are joined to each other by chemical bonds
- F. exist as a solid in the form of an ionic lattice
- G. oppositely charged ions attract each other
- H. molecule made of uncharged atoms
- I. bond between atoms is due to electron transfer
- J. compound is made of a non-metal and a non-metal
- K. sodium chloride (NaCl) is an example
- L. water (H₂O) is an example

Ionic compound	Both	Covalent compound
A G C I F J K	B, E	D, H, L

Compounds Review

Match each Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. <u>E</u> molecule	A. pure substance made of one type of atom
2. <u>C</u> ionic lattice	B. atoms combine by gaining or losing electrons
3. <u>F</u> polyatomic ion	C. repeating pattern of positive and negative ions
4. <u>B</u> ionic compound	D. atoms combine by sharing electrons to form molecules
5. <u>D</u> covalent compound	E. neutral particle that is made up of atoms that are joined together by covalent bonds
	F. ion made up of two or more atoms that are held together with covalent bonds

Circle the letter of the best answer.

6. Atoms in non-metals tend to gain
- A. molecules
 - B. ions
 - C. atoms
 - D. electrons

7. Which of the following can be formed when there is electron transfer between metals and non-metals?
- A. molecule
 - B. element
 - C. ionic bond
 - D. covalent bond

8. Which of the following is formed due to the sharing of electrons between two non-metals?

I.	a molecule
II.	a covalent bond
III.	a covalent compound

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II, and III

9. Water is a(n)

- A. element
- B. polyatomic ion
- C. ionic compound
- D. covalent compound

10. Sodium chloride is a(n)

- A. element
- B. polyatomic ion
- C. ionic compound
- D. covalent compound

11. Which of the following can be formed when a non-metal atom reacts with a non-metal atom?

- A. element
- B. polyatomic ion
- C. ionic compound
- D. covalent compound