

Name: _____ Period: _____ Date: _____

Ionic Bonding

Learning goal

I can model electron transfer between metals and nonmetals and use it to find the formula of an ionic compound.

Part 1 · Notes

Fill in each blank using the word bank for that section.

Section A · Electron Transfer Makes Ions

Word bank

3- · 2+ · 6+ · shares · 3+ · 2- · gains · 13+ · loses

- When a metal bonds with a nonmetal, the metal _____ its valence electrons and the nonmetal gains them. This is **electron transfer**. The result is a positive ion and a negative ion that attract: an **ionic bond**.
- The charge on each ion comes from how many electrons it loses or gains to reach an octet:

Group	1	2	13	15	16	17
Electrons	lose 1	lose 2	lose 3	gain 3	gain 2	gain 1
Ion charge	1+	2+	3+	3-	2-	1-

- Aluminum is in Group 13, so its ion has a charge of _____.
- Oxygen is in Group 16, so it gains 2 electrons and its ion has a charge of _____.

Section B · When the Numbers Don't Match

Word bank

zero · positive · 2 · two magnesium ions · 7 · 1 ·
two chloride ions · negative

- Sodium gives away 1 electron and chlorine takes 1, so one of each works. Magnesium has **2** electrons to give, but one chlorine can take only _____. A second chlorine atom is needed.

Remember

Electrons lost = electrons gained. The positive and negative charges cancel, so the total charge of an ionic compound is _____.

- The formula shows the ratio of ions. In MgCl_2 , the small 2 means _____ for every magnesium ion.

Section C · The Crystal Lattice

Word bank

zero · opposite · same

- In a real grain of salt there are no separate “NaCl pairs.” Trillions of Na^+ and Cl^- ions stack in a repeating 3D pattern called a **crystal lattice**. Each ion is surrounded by ions of the _____ charge.
- Because an ionic compound isn't made of separate molecules, its formula describes a **formula unit**: the smallest whole-number ratio of ions.

Remember

Every ion in the lattice is attracted to the ions around it in every direction. Keep that in mind; it's a clue about salt's 801 °C melting point (C7.14).

Part 2 · Electron Transfer Builder

Use the atom cards and cut-out electrons from your teacher, or draw the dots. Move electrons from metal atoms to nonmetal atoms. If someone still has electrons to give or room to take, add another atom. Keep going until every atom is stable.



Card 1 · One to one (do this after Section A)

For each pair: **(1)** write how many electrons the metal gives and the nonmetal takes. **(2)** Write how many of each atom you needed. **(3)** Check that electrons given = electrons taken. **(4)** Write the ions you made and the formula. The first row is done for you.

Metal + nonmetal	Metal gives	Nonmetal takes	Atoms needed (metal : nonmetal)	Given = taken	Ions	Formula
<i>Ex: K + Br</i>	1	1	1 : 1	1 = 1	K ⁺ Br ⁻	KBr
Na + Cl						
Mg + O						
Li + F						

In Mg + O, magnesium gave away 2 electrons. Why was one oxygen enough to take both?

Sentence stem: "One oxygen was enough because Mg gives ____ electrons and O needs ____ electrons, so ____."

Card 2 · Unequal ratios (do this after Section B)

Start with one of each atom. When the numbers don't match, add an atom to the side that gives or takes fewer electrons. Write the formula with the smallest whole-number ratio: metal first, and a subscript only when there's more than 1. In the example, Ca gives 2 but each Br takes only 1, so a second Br is added.

Metal + nonmetal	Metal gives	Nonmetal takes	Atoms needed (metal : nonmetal)	Given = taken	Ions	Formula
<i>Ex: Ca + Br</i>	2	1	1 : 2	2 = 2	Ca ²⁺ Br ⁻ Br ⁻	CaBr ₂
Mg + Cl						
Na + O						
Al + F						

Na₂O needed two sodium atoms, but MgCl₂ needed two chlorine atoms. Why did the extra atom end up on different sides?

Sentence stem: "Na₂O needed two Na because _____. MgCl₂ needed two Cl because _____."

Card 3 · Aluminum + oxygen (do this in Section C)

Each Al gives 3 and each O takes 2. Add atoms one at a time until the tally matches.

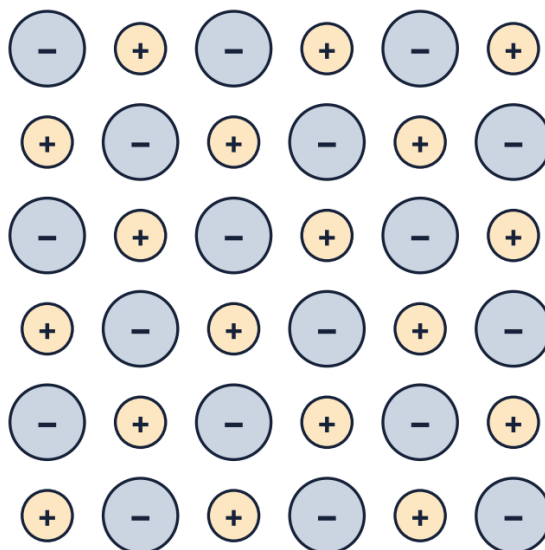
Electrons given: _____ Electrons taken: _____ Al atoms: _____ O atoms: _____

Formula: _____

Al_2O_3 needed 2 aluminum atoms and 3 oxygen atoms. Explain how the electrons decided those numbers.

Sentence stem: "Each Al gives ____ and each O takes _____. The smallest number both go into is _____, so _____."

Lattice sheet: this is part of a salt (NaCl) crystal. Real ionic compounds repeat their ratio like this in every direction. Circle one formula unit.



Part 3 · Checkpoints

How to use this section

1. Answer the ▲ main questions for each checkpoint.
2. Check your answers with your teacher.
3. Your teacher may give you a ● or ■ page for that checkpoint. Finish it before you move on.

Checkpoint 1 · Ion charges

▲ Main questions

T1.1. What is the charge on an aluminum ion (Group 13)?

- A. 3+
- B. 13+
- C. 5-
- D. 3-

T1.2. Nitrogen (Group 15) gains electrons to reach an octet. What is the charge on its ion?

- A. 5-
- B. 3-
- C. 5+
- D. 3+

T1.3. Which list shows the correct ion charges for potassium, calcium, and aluminum, in that order?

- A. 1+, 1+, 1+
- B. 3+, 2+, 1+
- C. 1+, 2+, 3+
- D. 1-, 2-, 3-

T1.4. Why does a magnesium ion have a 2+ charge?

- A. It gains 2 protons
- B. It gains 2 electrons
- C. It loses 2 protons
- D. It loses 2 electrons, so it has 2 more protons than electrons

Checkpoint 2 · Ratios from electron transfer

▲ Main questions

T2.1. Calcium forms Ca^{2+} and fluorine forms F^- . What is the formula of their compound?

- A. CaF_2
- B. Ca_2F
- C. CaF
- D. Ca_2F_2

T2.2. Sodium and oxygen bond. How many sodium atoms are needed for each oxygen atom?

- A. 3
- B. 2
- C. 1
- D. 6

T2.3. Aluminum forms Al^{3+} and fluorine forms F^- . What is the formula of their compound?

- A. Al_3F
- B. AlF
- C. AlF_3
- D. Al_2F_3

T2.4. What does the formula MgCl_2 tell you?

- A. There are 2 magnesium ions for every chloride ion
- B. One molecule has 1 Mg and 2 Cl atoms sharing electrons
- C. Magnesium has a 2- charge
- D. There are 2 Cl^- ions for every Mg^{2+} ion

Part 4 · Claim, Evidence, Reasoning

Question: The formula for magnesium chloride is MgCl_2 , not MgCl . Explain why, using valence electrons and electron transfer as evidence.

	Mg	Cl
Group	2	17
Valence electrons	2	7
Electrons lost or gained	loses 2	gains 1
Ion	Mg^{2+}	Cl^-

Sentence stems (use them if you need them)

I claim that magnesium chloride is MgCl_2 because ____.

My evidence is that magnesium loses ____ electrons and each chlorine gains ____ electron.

This means ____ chlorine atoms are needed, because electrons lost must equal ____.

Evidence bank: Mg: 2 valence electrons · Cl: 7 valence electrons · Mg loses 2 $\rightarrow \text{Mg}^{2+}$ · each Cl gains 1 $\rightarrow \text{Cl}^-$ · electrons lost = electrons gained · $+2$ and $2 \times (-1) = 0$

Claim:

Evidence:

Reasoning:

■ Take it further

Someone says the formula should be MgCl , because one magnesium and one chlorine bond one-to-one, like sodium and chlorine. Explain why that's wrong.

Glossary · Glosario · Bảng thuật ngữ

English	Español	Tiếng Việt
electron transfer: the movement of electrons from a metal atom to a nonmetal atom, forming ions	transferencia de electrones: el paso de electrones de un átomo de metal a un átomo de no metal, formando iones	sự chuyển electron: sự di chuyển electron từ nguyên tử kim loại sang nguyên tử phi kim, tạo thành ion
formula unit: the smallest whole-number ratio of ions in an ionic compound	unidad fórmula: la menor proporción de números enteros de iones en un compuesto iónico	đơn vị công thức: tỉ lệ số nguyên nhỏ nhất giữa các ion trong hợp chất ion
crystal lattice: a repeating 3D pattern of ions in a solid	red cristalina: un patrón tridimensional repetido de iones en un sólido	mạng tinh thể: sự sắp xếp lặp lại theo ba chiều của các ion trong chất rắn

Key directions · Instrucciones · Hướng dẫn

English	Español	Tiếng Việt
Drag electrons from the metal to the nonmetal.	Arrastra electrones del metal al no metal.	Kéo electron từ kim loại sang phi kim.
Add another atom if someone still has electrons to give or room to take.	Agrega otro átomo si alguien todavía tiene electrones para dar o espacio para recibir.	Thêm một nguyên tử nếu vẫn còn electron để cho hoặc chỗ để nhận.
Keep going until every atom is stable.	Sigue hasta que cada átomo sea estable.	Tiếp tục cho đến khi mọi nguyên tử đều bền.
Write a claim, evidence, and reasoning.	Escribe una afirmación, evidencia y razonamiento.	Viết nhận định, bằng chứng và lập luận.

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Checkpoint 1 · Ion charges

- Your teacher gave you this page. Finish it before you move on to the next section.

• Need a boost?

S1.1. Magnesium is in Group 2 and loses 2 electrons. What is the charge on its ion?

- A. 0
- B. 2+
- C. 2-

S1.2. Fluorine is in Group 17 and gains 1 electron. What is the charge on its ion?

- A. 7-
- B. 1+
- C. 1-

S1.3. When sodium and chlorine bond, which atom loses an electron?

Circle one: **Na** or **Cl**

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Checkpoint 2 · Ratios from electron transfer

- Your teacher gave you this page. Finish it before you move on to the next section.

• Need a boost?

Remember: electrons given = electrons taken.

S2.1. Sodium gives away 1 electron and chlorine takes 1 electron. How many chlorine atoms are needed for each sodium?

- A. 1
- B. 7
- C. 2

S2.2. Magnesium must give away 2 electrons, but each chlorine can take only 1. How many chlorine atoms are needed?

- A. 7
- B. 2
- C. 1

S2.3. What is the formula of the compound made from magnesium and chlorine?

- A. Mg_2Cl
- B. MgCl
- C. MgCl_2

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Checkpoint 1 · Ion charges

■ Your teacher gave you this page. Try these after your main questions.

■ Take it further

H1.1. Element X forms ions with a 3+ charge. Which group is X most likely in?

- A. Group 17
- B. Group 1
- C. Group 13
- D. Group 15

H1.2. Which ion required the most electrons to move when it formed?

- A. O^{2-}
- B. Na^+
- C. Cl^-
- D. N^{3-}

H1.3. Explain why the ion charges for Groups 15, 16, and 17 are 3-, 2-, and 1-.

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Checkpoint 2 · Ratios from electron transfer

■ Your teacher gave you this page. Try these after your main questions.

■ Take it furtherH2.1. Al^{3+} and O^{2-} form Al_2O_3 . How many electrons are transferred in one formula unit?

- A. 2
- B. 3
- C. 5
- D. 6

H2.2. Calcium forms Ca^{2+} and nitrogen forms N^{3-} . What is the formula of their compound?

- A. Ca_3N_2
- B. CaN
- C. Ca_2N_3
- D. Ca_3N

H2.3. A student writes the formula of magnesium chloride as Mg_2Cl_4 . Explain what's wrong.
