

Name: _____ Period: _____ Date: _____

Polyatomic Ions

Learning goal

I can write and name compounds that contain polyatomic ions.

Part 1 · Notes

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

Section A · Ions Made of Several Atoms

Word bank

acts as one ion · SO_3^{2-} · positive

- So far every ion was one atom: Na^+ , Cl^- , O^{2-} . A **polyatomic ion** is a group of atoms that stays together and carries **one** charge for the whole group. Nitrate, NO_3^- , is one nitrogen and three oxygens with a 1- charge for all four atoms together.
- The atoms inside a polyatomic ion share electrons; those bonds are covalent (C7.08). In a compound, the whole group _____.

In SO_4^{2-}	Means
S, O	the elements
the 4 in SO_4	4 oxygen atoms (inside the ion; never change it)
the 2-	the charge of the whole ion

- Use the class ion sheet.** You don't need to memorize all 19 ions today. But look for patterns:
- ate and -ite:** the -ite ion has **one fewer oxygen** and the **same charge**. Sulfate is SO_4^{2-} , so sulfite is _____.
- The chlorine family:** perchlorate ClO_4^- → chlorate ClO_3^- → chlorite ClO_2^- → hypochlorite ClO^- . All are 1-.
- Hydrogen carbonate** HCO_3^- is carbonate (CO_3^{2-}) plus H^+ , so its charge is 1-.
- Ammonium, NH_4^+ , is the only _____ ion on the sheet.

The class ion sheet

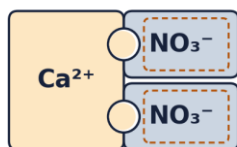
Ion	Formula	Ion	Formula
acetate	$\text{C}_2\text{H}_3\text{O}_2^-$	hypochlorite	ClO^-
ammonium	NH_4^+	nitrate	NO_3^-
carbonate	CO_3^{2-}	nitrite	NO_2^-
chlorate	ClO_3^-	perchlorate	ClO_4^-
chlorite	ClO_2^-	permanganate	MnO_4^-
chromate	CrO_4^{2-}	phosphate	PO_4^{3-}
cyanide	CN^-	phosphite	PO_3^{3-}
dichromate	$\text{Cr}_2\text{O}_7^{2-}$	sulfate	SO_4^{2-}
hydrogen carbonate	HCO_3^-	sulfite	SO_3^{2-}
hydroxide	OH^-		

Section B · The Parentheses Rule

Word bank

two · more than one

- Write formulas exactly as in C7.04: balance the charges, then write the smallest ratio. Treat the polyatomic ion as **one piece**.
- Worked example: calcium nitrate.** Ca^{2+} and NO_3^- . One Ca^{2+} (+2) needs _____ NO_3^- ions (−1 each).



$\text{Ca}(\text{NO}_3)_2$: $(+2) + 2(-1) = 0$



CaCO_3 : one of each, no parentheses

- To show two nitrate ions, put the whole ion in **parentheses** and write the subscript outside: **$\text{Ca}(\text{NO}_3)_2$** . Without parentheses, “ CaNO_{32} ” would mean 32 oxygens!

Formula	Why
$\text{Ca}(\text{NO}_3)_2$	2 nitrate ions → parentheses
CaCO_3	1 carbonate ion → no parentheses
NH_4Cl	1 ammonium ion → no parentheses
$(\text{NH}_4)_2\text{SO}_4$	2 ammonium ions → parentheses

- Parentheses go around a polyatomic ion only when there is _____ of it. Never change the small numbers inside the ion: hydroxide is always OH, sulfate is always SO_4 .
- Counting atoms:** in $\text{Ca}(\text{NO}_3)_2$, the 2 multiplies everything inside the parentheses: 1 Ca, 2 N, 6 O.

Section C · Naming Compounds with Polyatomic Ions

Word bank

doesn't change

- Naming works just like C7.05: the positive ion first, then the negative ion, and no prefixes. **A polyatomic ion keeps its own name.**

Formula	Name
NaOH	sodium hydroxide
CaCO ₃	calcium carbonate
NH ₄ Cl	ammonium chloride
Al ₂ (SO ₄) ₃	aluminum sulfate

- Watch two traps: hydroxide and cyanide end in -ide but are **polyatomic** (OH⁻, CN⁻); and KNO₃ is potassium nit**rate** while KNO₂ is potassium nit**rite**. Count the oxygens.
- The name of a polyatomic ion _____ when it's in a compound.

Part 2 · Build It

Card 1 · Ion Builder (do this after Section A)

Use the class ion sheet for the first six. For the last two, don't look: start from the -ate ion you built and use the pattern.

Ion name	Atoms (element × how many)	Charge	Formula with charge
nitrate			
sulfate			
carbonate			
ammonium			
hydroxide			
phosphate			
sulfite (from sulfate)			
nitrite (from nitrate)			

Sulfate and sulfite have the same charge but different numbers of oxygen atoms. How did you build sulfite from sulfate?

Sentence stem: "Sulfate is ____ and sulfite is _____. I _____, and the charge _____."

Card 2 · Polyatomic pieces (do this after Section B)

Cut out the pieces on the next page. Add pieces until every tab fills a notch, then write the formula. Use parentheses only when there's more than one polyatomic ion. Then count the atoms.

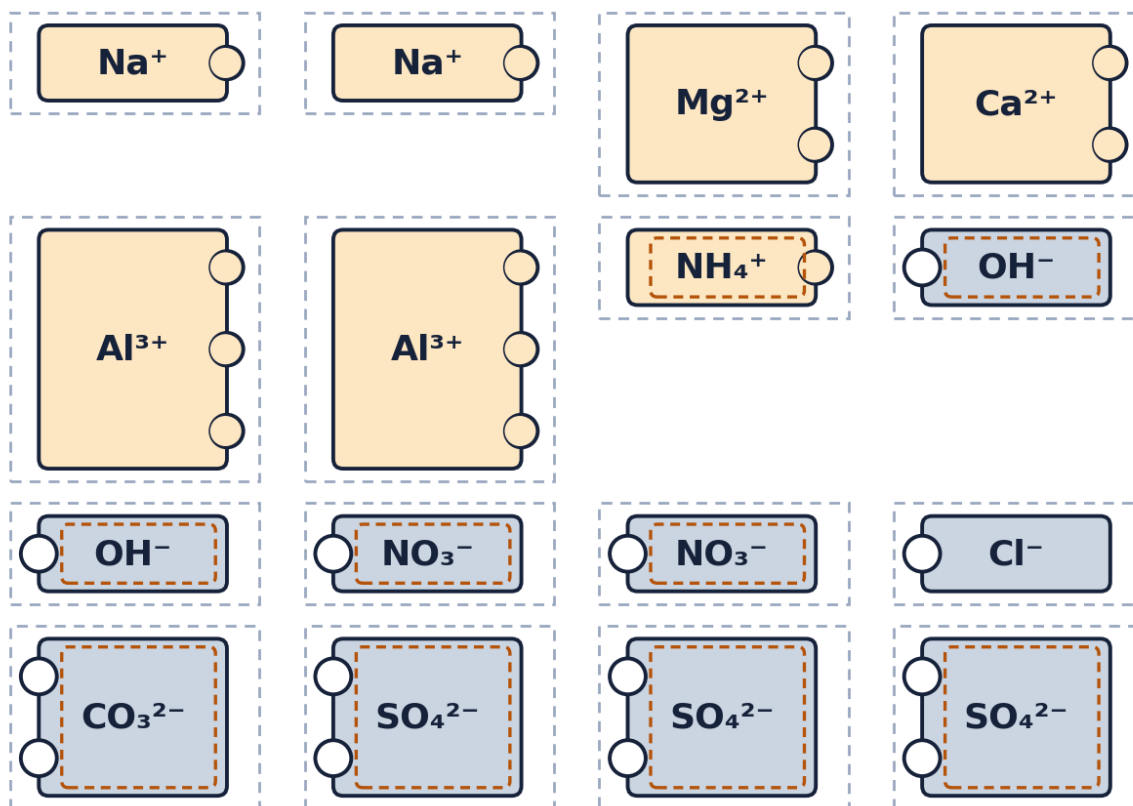
Ions	Pieces (+ : -)	+ total	- total	Formula	Atoms in one formula unit
$\text{Na}^+ + \text{OH}^-$					
$\text{Ca}^{2+} + \text{NO}_3^-$					
$\text{Na}^+ + \text{CO}_3^{2-}$					
$\text{NH}_4^+ + \text{Cl}^-$					
$\text{Mg}^{2+} + \text{OH}^-$					
$\text{Al}^{3+} + \text{SO}_4^{2-}$					

$\text{Ca}(\text{NO}_3)_2$ has parentheses but CaCO_3 doesn't. What decides when you need them?

Sentence stem: " $\text{Ca}(\text{NO}_3)_2$ needs parentheses because _____. CaCO_3 doesn't because _____."

Polyatomic pieces · cut along the dashed lines

Tabs (+) are bumps; notches (−) are holes. A dashed bracket marks a polyatomic ion: it moves as one piece.



Card 3 · Polyatomic race with a partner (do this in Section C)

Cut out the 8 cards on the next page and fold each one on the dotted line. Your partner holds up a card's FRONT; you answer; your partner checks the BACK. A wrong card goes to the bottom of the pile. Then switch.

Card	My answer	Right? (partner checks)	Card	My answer	Right?
1			5		
2			6		
3			7		
4			8		

Which card was the trickiest to name or write, and what did you check to get it right?

Sentence stem: "The trickiest card was ____ because _____. I checked _____."

Race cards · cut along the dashed lines, fold on the dotted line

Front: the question. Back: the answer. Fold so the back faces away from the player.

NaOH FRONT · name it	sodium hydroxide BACK · answer
KNO₃ FRONT · name it	potassium nitrate BACK · answer
CaCO₃ FRONT · name it	calcium carbonate BACK · answer
NH₄Cl FRONT · name it	ammonium chloride BACK · answer
magnesium hydroxide FRONT · write the formula	Mg(OH)₂ BACK · answer
sodium sulfate FRONT · write the formula	Na₂SO₄ BACK · answer
calcium nitrate FRONT · write the formula	Ca(NO₃)₂ BACK · answer
ammonium phosphate FRONT · write the formula	(NH₄)₃PO₄ BACK · answer

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 · Identify polyatomic ions

▲ Main questions

T1.1. Which ion on the class sheet is positive?

- A. ammonium, NH_4^+
- B. acetate, $\text{C}_2\text{H}_3\text{O}_2^-$
- C. hydroxide, OH^-
- D. nitrate, NO_3^-

T1.2. How many oxygen atoms are in one phosphate ion, PO_4^{3-} ?

- A. 7
- B. 4
- C. 3
- D. 1

T1.3. Which two ions have the same charge?

- A. phosphate and carbonate
- B. ammonium and hydroxide
- C. sulfate and carbonate
- D. sulfate and nitrate

T1.4. In CaCO_3 , which part is the polyatomic ion?

- A. the whole CaCO_3
- B. Ca^{2+}
- C. O^{2-}
- D. CO_3^{2-}

Checkpoint 2 · Formulas with parentheses

▲ Main questions

T2.1. What is the formula for magnesium hydroxide?

- A. MgOH_2
- B. $\text{Mg}(\text{OH})_2$
- C. MgOH
- D. Mg_2OH

T2.2. What is the formula for ammonium chloride?

- A. NH_4Cl_2
- B. $(\text{NH}_4)\text{Cl}$
- C. NH_4Cl
- D. $(\text{NH}_4)_2\text{Cl}$

T2.3. What is the formula for aluminum sulfate?

- A. $\text{Al}_2\text{SO}_{43}$
- B. $\text{Al}(\text{SO}_4)_3$
- C. $\text{Al}_3(\text{SO}_4)_2$
- D. $\text{Al}_2(\text{SO}_4)_3$

T2.4. How many oxygen atoms are in one formula unit of $\text{Ca}_3(\text{PO}_4)_2$?

- A. 8
- B. 2
- C. 4
- D. 6

Part 4 · Claim, Evidence, Reasoning

Question: A student writes the formula for calcium hydroxide as CaOH_2 . Explain why the correct formula is $\text{Ca}(\text{OH})_2$, using the charges and what the subscript means. (Ca^{2+} : charge +2. OH^- : charge -1, with 1 O and 1 H.)

Formula	Ca	O	H
CaOH_2	1	1	2
$\text{Ca}(\text{OH})_2$	1	2	2

Sentence stems (use them if you need them)

I claim that the correct formula is ____.

My evidence is that Ca^{2+} needs ____ OH^- ions because _____. CaOH_2 shows ____ O and ____ H.

This means the parentheses are needed because a subscript _____.

Evidence bank: Ca^{2+} · OH^- · $(+2) + 2(-1) = 0$ · two hydroxide ions · a subscript applies to the symbol before it · parentheses group the whole ion

Claim:

Evidence:

Reasoning:

■ Take it further

Someone says CaO_2H_2 is just as good, since it has the same atoms. Respond.

Glossary · Glosario · Bảng thuật ngữ

English	Español	Tiếng Việt
polyatomic ion: a group of atoms that stays together and carries one charge, such as NO_3^-	ion poliatómico: un grupo de átomos que se mantiene unido y tiene una sola carga, como NO_3^-	ion đa nguyên tử: nhóm nguyên tử luôn đi cùng nhau và mang chung một điện tích, như NO_3^-
parentheses: the marks () placed around a polyatomic ion when a formula has more than one of it, as in $\text{Ca}(\text{NO}_3)_2$	paréntesis: los signos () que se ponen alrededor de un ion poliatómico cuando la fórmula tiene más de uno, como en $\text{Ca}(\text{NO}_3)_2$	dấu ngoặc đơn: ký hiệu () đặt quanh một ion đa nguyên tử khi công thức có nhiều hơn một ion đó, như $\text{Ca}(\text{NO}_3)_2$
-ate / -ite: endings for related polyatomic ions; the -ite ion has one fewer oxygen atom and the same charge (sulfate SO_4^{2-} , sulfite SO_3^{2-})	-ato / -ito: terminaciones de iones poliatómicos relacionados; el ion -ito tiene un átomo de oxígeno menos y la misma carga (sulfato SO_4^{2-} , sulfito SO_3^{2-})	-at / -it: đuôi tên của các ion đa nguyên tử liên quan; ion -it có ít hơn một nguyên tử oxi và cùng điện tích (sunfat SO_4^{2-} , sunfit SO_3^{2-})

Key directions · Instrucciones · Hướng dẫn

English	Español	Tiếng Việt
Build the ion: pick the atoms and the charge.	Construye el ion: elige los átomos y la carga.	Ghép ion: chọn các nguyên tử và điện tích.
Put parentheses around the ion if there is more than one.	Pon paréntesis alrededor del ion si hay más de uno.	Đặt dấu ngoặc quanh ion nếu có nhiều hơn một.
Open the ion sheet if you need it.	Abre la hoja de iones si la necesitas.	Mở bảng ion nếu em cần.
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 · Identify polyatomic ions

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

• Need a boost?

Ion sheet: nitrate NO_3^- · chloride Cl^- (one atom) · sodium Na^+ (one atom) · sulfate SO_4^{2-} · hydroxide OH^- · oxide O^{2-} (one atom)

S1.1. Which of these is a polyatomic ion?

- A. Na^+
- B. NO_3^-
- C. Cl^-

S1.2. What is the charge of the sulfate ion, SO_4^{2-} ?

- A. 1-
- B. 4-
- C. 2-

S1.3. Which name goes with OH^- ?

- A. hydroxide
- B. oxide
- C. hydrogen

Name: _____ Period: _____ Date: _____

Checkpoint 2 · Formulas with parentheses

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

• Need a boost?S2.1. Na^+ and OH^- . What is the formula?

- A. Na_2OH
- B. NaOH
- C. $\text{Na}(\text{OH})_2$

S2.2. One Ca^{2+} needs two NO_3^- . What is the formula?

- A. Ca_2NO_3
- B. CaNO_{32}
- C. $\text{Ca}(\text{NO}_3)_2$

S2.3. Does CaCO_3 need parentheses?Circle one: **No** or **Yes**

Name: _____ Period: _____ Date: _____

Checkpoint 1 · Identify polyatomic ions

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

■ Take it furtherH1.1. Nitrate is NO_3^- . What is nitrite?

- A. NO_4^-
- B. NO_2^{2-}
- C. NO_3^{2-}
- D. NO_2^-

H1.2. Which list puts the chlorine family in order from most to fewest oxygen atoms?

- A. perchlorate, chlorate, chlorite, hypochlorite
- B. chlorate, perchlorate, chlorite, hypochlorite
- C. perchlorate, chlorite, chlorate, hypochlorite
- D. hypochlorite, chlorite, chlorate, perchlorate

H1.3. Carbonate is CO_3^{2-} , but hydrogen carbonate is HCO_3^- . Explain why the charge changes.

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Checkpoint 2 · Formulas with parentheses

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

■ Take it furtherH2.1. A student writes calcium hydroxide as CaOH_2 . What's wrong?

- A. Nothing is wrong
- B. Hydroxide has a 2- charge
- C. Calcium should have a subscript of 2
- D. Without parentheses the 2 applies only to H, so it shows one O instead of two OH^- ions

H2.2. What is the formula for ammonium sulfate?

- A. $(\text{NH}_4)_2\text{SO}_4$
- B. $\text{NH}_4(\text{SO}_4)_2$
- C. NH_4SO_4
- D. $(\text{NH}_4)\text{SO}_4$

H2.3. Write the formula for barium nitrate and explain why it has parentheses.
