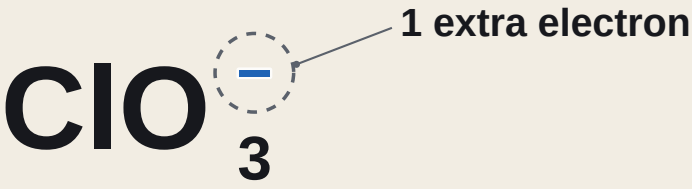
A8 · Electron dot diagrams for polyatomic ions · Completed notes

Goals: Explain why bonding capacity cannot build a polyatomic ion. Count the valence electrons of a molecule or an ion, using the charge. Draw the electron dot diagram of a polyatomic ion in five steps.

These are the completed notes. The blanks are filled in and each question is worked.

Slide 1 of 6 · When bonding capacity is not enough

In lessons A5 and A6, bonding capacity built every molecule. In A1 you also met ions made of several atoms. Bonding capacity cannot build those.



Chlorine forms 1 bond, but here it is joined to 3 atoms.

Key ideas

A polyatomic ion is a group of atoms with a **charge**.

The chlorate ion has a charge of 1−, so it has 1 **extra electron**.

Bonding capacity does not work for an ion.

Example

The nitrate ion is NO_3^-. How many extra electrons does it have?

1. Its charge is 1−.
2. So it has 1 extra electron.

Try it

The sulfate ion is SO_4^{2-}. How many extra electrons does it have?

1. Its charge is 2−.
2. So it has 2 extra electrons.

Slide 2 of 6 · The five steps, on a molecule

The last slide said a new method is needed. Test it first on $COCl_2$, the molecule from lesson A6. The answer should match.

1

Atom	Each	How many	Electrons
C	4	1	4
O	6	1	6
Cl	7	2	14
total			24

2



3 bonds use 6.

Key ideas

Step 1: **count** the valence electrons.

Step 2: **connect**. Join each outer atom to the middle atom.

Step 3: **fill** the outer atoms with lone pairs.

Step 5: **move** a lone pair in if the middle atom has only 6.

Example

How many valence electrons are in carbon dioxide, CO_2? Show your count.

1. Carbon has 4. Each oxygen has 6, and there are 2.
2. 4 + 6 + 6 = 16 valence electrons.

Try it

How many valence electrons are in nitrogen trifluoride, NF_3? Show your count.

1. Nitrogen has 5. Each fluorine has 7, and there are 3.
2. 5 + 7 + 7 + 7 = 26 valence electrons.

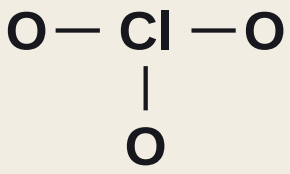
Slide 3 of 6 · A negative ion

The five steps worked on a molecule. Now use them on the chlorate ion from slide 1. A negative charge changes only step 1.

1

Atom	Each	How many	Electrons
Cl	7	1	7
O	6	3	18
charge −			+ 1
total			26

2



3 bonds use 6.

Key ideas

For a negative ion, **add** electrons for the charge.

Put the finished diagram in **square brackets**.

Write the charge outside, at the **top right**.

Example

How many valence electrons are in the hydroxide ion, OH^-? Show your count.

1. Oxygen has 6. Hydrogen has 1.
2. Add 1 electron for the charge 1−.
3. 6 + 1 + 1 = 8 valence electrons.

Try it

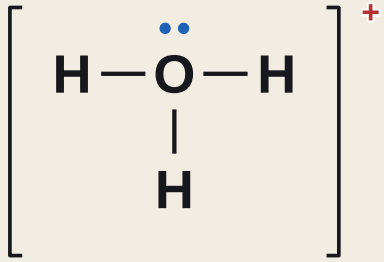
How many valence electrons are in the nitrate ion, NO_3^-? Show your count.

1. Nitrogen has 5. Each oxygen has 6, and there are 3.
2. Add 1 electron for the charge 1−.
3. 5 + 18 + 1 = 24 valence electrons.

Slide 4 of 6 · A positive ion

On the last slide, a negative charge added electrons in step 1. A positive charge also changes only step 1. It takes electrons away.

Atom	Each	How many	Electrons
H	1	3	3
O	6	1	6
charge +			− 1
total			8



Key ideas

For a positive ion, **take away** electrons for the charge.

Hydrogen is never the **middle atom**.

In H_3O^+ the total is **8** valence electrons.

Example

How many valence electrons are in the ammonium ion, NH_4^+? Where do they go?

1. Nitrogen has 5. Each hydrogen has 1, and there are 4.
2. Take away 1 for the charge 1+. 5 + 4 − 1 = 8.
3. Nitrogen is in the middle. The 4 bonds use all 8 electrons.

Try it

How many valence electrons are in the phosphonium ion, PH_4^+? Show your count.

1. Phosphorus has 5. Each hydrogen has 1, and there are 4.
2. Take away 1 for the charge 1+. 5 + 4 − 1 = 8.

Slide 5 of 6 · Method: how to draw the electron dot diagram of a polyatomic ion

You have now used the five steps on a molecule and four ions. Here are the five steps on one card.

1. **Count** the valence electrons. Adjust for the charge.
2. **Connect** the middle atom to each outer atom.
3. **Fill** the outer atoms to 8. Hydrogen has 2.
4. **Put** left-over electrons on the middle atom.
5. **Move** a lone pair in if the middle has under 8.



Check: electrons drawn equal electrons counted.

Used again in: lesson A9

Key ideas

Step 1: **count**. Step 2: **connect**.

Step 3: **fill** the outer atoms.

Step 4: put what is **left over** on the middle atom.

Step 5: **move** a pair in, if the middle atom is short.

Example

Use the five steps on the carbonate ion, CO_3^{2-}.

1. Step 1: 4 + 18 + 2 = 24.
2. Step 2: carbon is in the middle. The 3 bonds use 6.
3. Step 3: each oxygen gets 3 lone pairs. That uses 18.
4. Step 4: 24 − 6 − 18 = 0, so none are left over. Carbon has only 6.
5. Step 5: move a lone pair in from one oxygen. Add brackets and 2−.

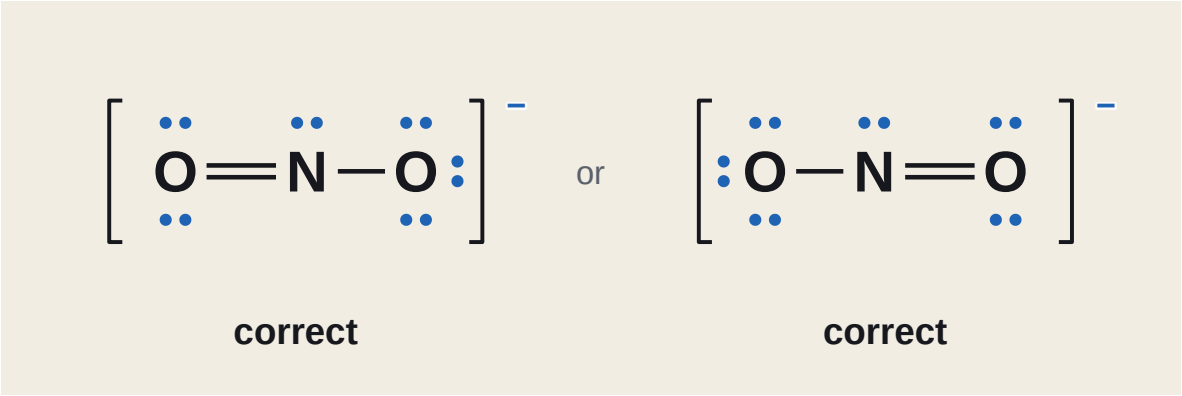
Try it

Use the five steps on the hydroxide ion, OH^-.

1. Step 1: 6 + 1 + 1 = 8.
2. Step 2: one bond joins O and H. It uses 2.
3. Step 3: oxygen gets 3 lone pairs. That uses 6.
4. Step 4: 8 − 2 − 6 = 0, so none are left over.
5. Step 5: no pair needs to move. Add brackets and 1−.

Slide 6 of 6 · More than one right answer

On slide 2, step 5 moved a lone pair in from oxygen. No other atom could give one. Sometimes step 5 gives you a choice.



Key ideas

The nitrite ion has **18** valence electrons.

After steps 1 to 4, nitrogen has only **6**.

The pair can come from **either one** of the oxygen atoms.

Example

In the carbonate ion, CO_3^{2-}, a lone pair must move in from an oxygen atom. How many correct drawings are there?

1. The 3 oxygen atoms are the same.
2. The pair can come from any one of them.
3. So there are 3 correct drawings. Draw one of them.

Try it

Why are both drawings of the nitrite ion correct?

1. The two oxygen atoms are the same.
2. So the lone pair can move in from either one.