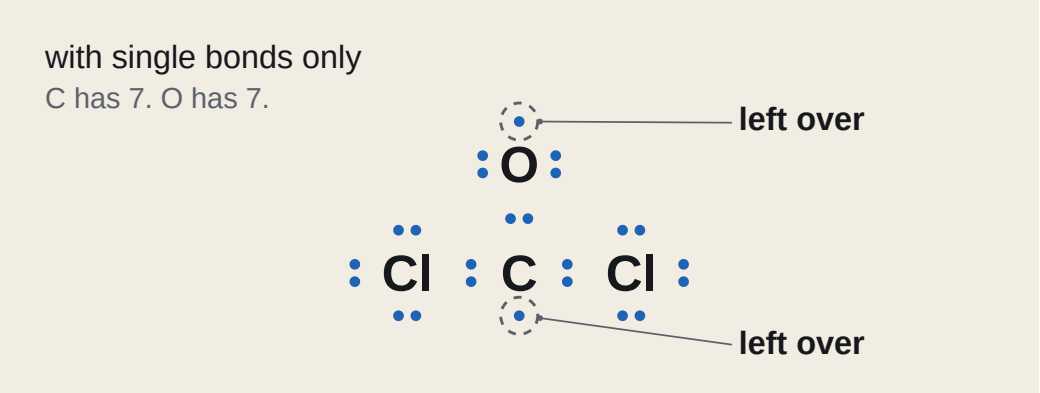
A6 · Double and triple bonds · Completed notes

Goals: Explain why two atoms share a second or a third pair of electrons. Draw electron dot diagrams and structural formulas for molecules with double and triple bonds. Draw molecules with two middle atoms, and check every atom.

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

Slide 1 of 6 · When single dots are left over: the double bond

In lesson A5, every molecule was drawn with single bonds. In some molecules, single bonds leave dots unshared. Today you see what the atoms do with those dots.



Key ideas

Left-over dots on joined atoms are shared as a **second pair**.

Two shared pairs between the same two atoms are a **double bond**.

In the structural formula, a double bond is **2** dashes.

Example

Formaldehyde is CH_2O. Carbon is the middle atom. After single bonds, which atoms have a dot left over? What do they do?

1. Carbon forms 4 bonds and has used 3, so it has 1 dot left over.
2. Oxygen forms 2 bonds and has used 1, so it has 1 left over.
3. Carbon and oxygen share the two dots as a second pair. That is a double bond.

Try it

In $COCl_2$, how many electrons are around the carbon atom? Show your count.

1. Carbon has 2 single bonds. That is 4 electrons.
2. It has 1 double bond. That is 4 more.
3. 4 + 4 = 8 electrons.

Slide 2 of 6 · The triple bond

On the last slide, carbon and oxygen shared two pairs. Two atoms can share three pairs too.

with single bonds only



C has 2 left over N has 2 left over

Key ideas

Three shared pairs between the same two atoms are a **triple bond**.

In the structural formula, a triple bond is **3** dashes.

In HCN, nitrogen has 8 electrons, with **1** lone pair.

Example

Nitrogen gas is N_2. Each nitrogen atom forms 3 bonds. What kind of bond joins the two atoms?

1. One single bond uses 1 dot from each atom.
2. Each atom has 2 dots left over, so they share 2 more pairs.
3. Three shared pairs are a triple bond.

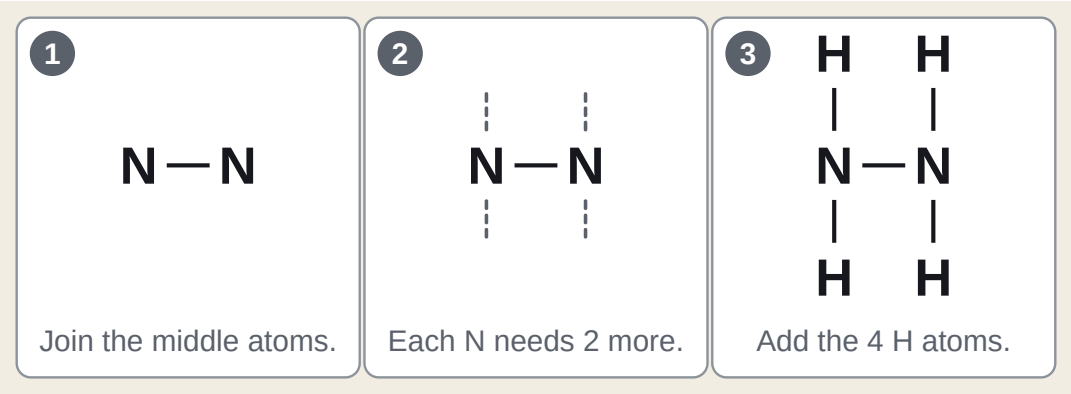
Try it

In the structural formula of HCN, how many dashes join C and N? How many join H and C?

1. A triple bond joins C and N, so there are 3 dashes.
2. A single bond joins H and C, so there is 1 dash.

Slide 3 of 6 · Molecules with two middle atoms

So far each molecule had one middle atom. Some molecules have two atoms that each form more than one bond. Both are middle atoms.



Key ideas

Step 1: join the two **middle atoms** first.

Step 2: **count** the dashes each middle atom still needs.

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

Example

Hydrogen peroxide is H_2O_2. Each oxygen forms 2 bonds. Use the three steps to find its structural formula.

1. Step 1: join the two oxygen atoms.
2. Step 2: each oxygen needs 1 more dash.
3. Step 3: add one hydrogen to each oxygen. The formula is H–O–O–H.

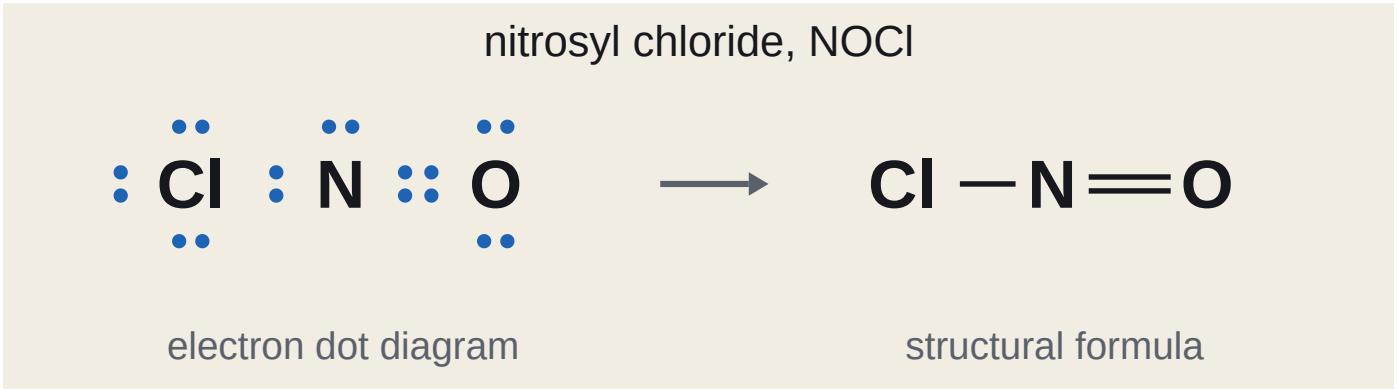
Try it

Ethane is C_2H_6. Each carbon forms 4 bonds. Use the three steps to find its structural formula.

1. Step 1: join the two carbon atoms.
2. Step 2: each carbon needs 3 more dashes.
3. Step 3: add 3 hydrogen atoms to each carbon. Every bond is a single bond.

Slide 4 of 6 · Multiple bonds between different atoms

On the last slide, the double bond joined two carbon atoms. The same steps work when the two joined atoms are different elements.



Key ideas

In NOCl, nitrogen forms 3 bonds, oxygen 2 and chlorine **1**.

So **nitrogen** is the middle atom.

NOCl has 1 single bond and 1 **double bond**.

Example

Carbon dioxide is CO_2. Carbon forms 4 bonds and each oxygen forms 2. What bonds join the atoms?

1. Carbon is the middle atom.
2. After single bonds, carbon has 2 dots left over and each oxygen has 1.
3. Carbon shares a second pair with each oxygen. So CO_2 has 2 double bonds.

Try it

In CS_2, what kind of bond joins carbon to each sulfur atom? Say why.

1. Carbon forms 4 bonds and each sulfur forms 2.
2. After single bonds, carbon has 2 dots left over and each sulfur has 1.
3. So a double bond joins carbon to each sulfur.

Slide 5 of 6 · Method: how to place double and triple bonds

You have now placed double bonds and a triple bond. Each time you did the same four things. Here they are as steps.

1. **Join** the atoms with single bonds.
2. **Find** atoms with single dots left over.
3. **Pair** left-over dots of two joined atoms.
4. **Count** the electrons around each atom.



Check: every atom has 8. Hydrogen has 2.

Used again in: lessons A8 and A9

Key ideas

Step 1: join the atoms with **single bonds**.

Step 2: find the dots that are **left over**.

Step 3: **pair** the left-over dots again.

Step 4: **count** the electrons at every atom.

Example

Use the four steps on oxygen gas, O_2. Each oxygen atom forms 2 bonds.

1. Step 1: join the two oxygen atoms with a single bond.
2. Step 2: each oxygen has 1 dot left over.
3. Step 3: pair the two dots. The bond is now a double bond.
4. Step 4: each oxygen has 4 shared electrons and 2 lone pairs. That is 8.

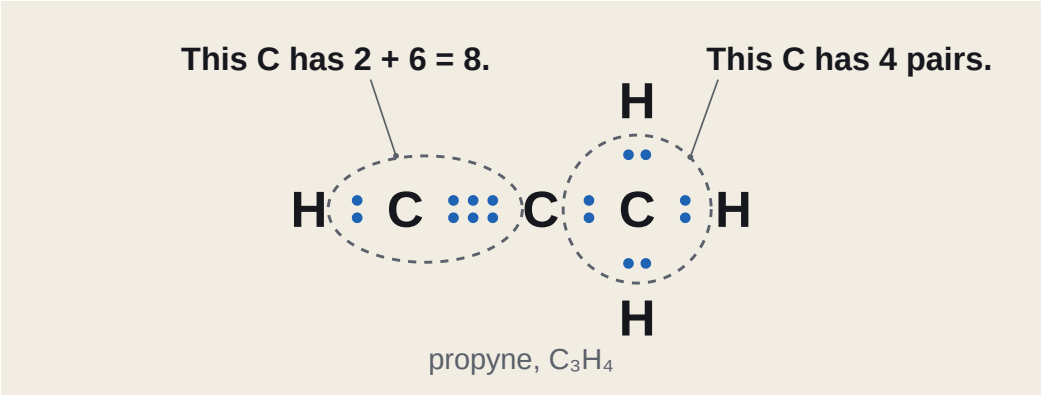
Try it

Use the four steps on ethyne, C_2H_2. Each carbon atom forms 4 bonds.

1. Step 1: join the two carbon atoms, and add one hydrogen to each.
2. Step 2: each carbon has 2 dots left over.
3. Step 3: pair them as 2 more pairs. The carbon atoms share a triple bond.
4. Step 4: each carbon has 2 + 6 = 8. Each hydrogen has 2.

Slide 6 of 6 · Check and draw

In lesson A5, the last step was to check every atom for 8 electrons. A double or triple bond changes how you count. It also changes how you draw.



propyne, C_3H_4

Key ideas

A double bond counts as **4** electrons.

A triple bond counts as **6**.

Draw the dashes of a double or triple bond **side by side**.

Example

In HCN, how many electrons are around the carbon atom? Show your count.

1. The single bond to hydrogen counts as 2.
2. The triple bond to nitrogen counts as 6.
3. 2 + 6 = 8 electrons.

Try it

In $COCl_2$, how many electrons are around the oxygen atom? Show your count.

1. The double bond to carbon counts as 4.
2. Oxygen has 2 lone pairs. That is 4 more.
3. 4 + 4 = 8 electrons.