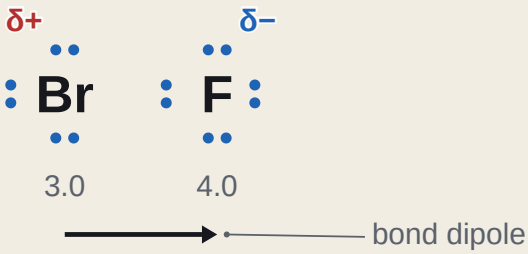
A10 · Polar and non-polar molecules · Notes

Goals: Explain what makes a molecule polar or non-polar. Use the shape of a molecule to decide whether its bond dipoles cancel. Decide whether a molecule is polar, and give the reason.

Name: _____ Date: _____

Slide 1 of 7 · From polar bonds to polar molecules

In lesson A7, a bond could be polar. In lesson A9, a molecule got a shape. Today you put the two together and ask if a whole molecule is polar.



a polar bond has a δ− end and a δ+ end

Key ideas

A _____ has a slightly negative side and a slightly positive side.

A _____ has no negative side and no positive side.

The bond dipole arrow points to the _____.

Example

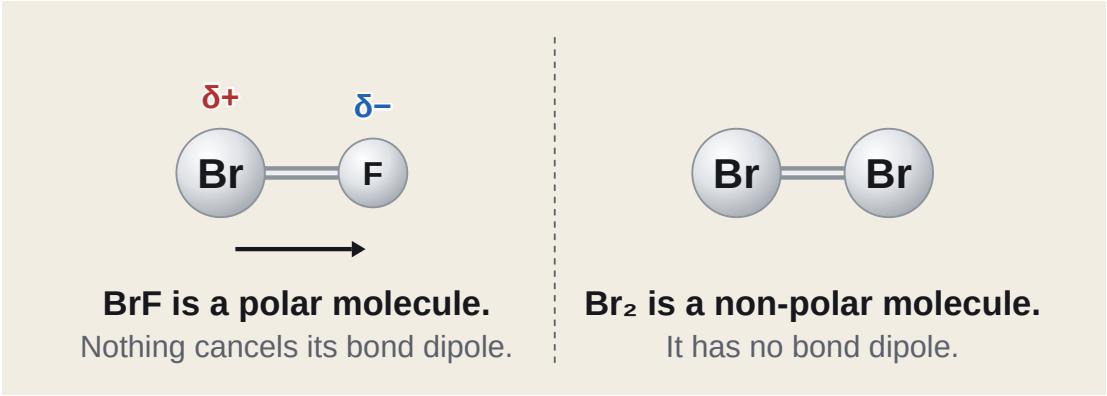
What is the difference between a polar bond and a polar molecule?

Try it

A molecule has no negative side and no positive side. What kind of molecule is it?

Slide 2 of 7 · A molecule with one bond

Start with the simplest case, a molecule with two atoms. It has only one bond, so that bond decides everything.



BrF is a polar molecule.
Nothing cancels its bond dipole.

Br_2 is a non-polar molecule.
It has no bond dipole.

Key ideas

A molecule with two different atoms has one _____.

Nothing can _____ it, so the molecule is polar.

Two atoms of the same element make a _____ molecule.

Example

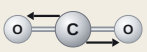
Is hydrogen chloride, HCl, a polar molecule? Say why.

Try it

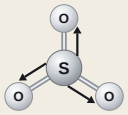
Is nitrogen gas, N_2, a polar molecule? Say why.

Slide 3 of 7 · Bond dipoles that cancel

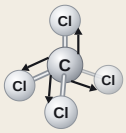
On the last slide, one polar bond made a polar molecule. With several polar bonds, the shape matters. The bonds can pull against each other.



carbon dioxide, CO_2
linear
2 equal arrows, opposite
non-polar molecule



sulfur trioxide, SO_3
trigonal planar
3 equal arrows, evenly spread
non-polar molecule



carbon tetrachloride, CCl_4
tetrahedral
4 equal arrows, evenly spread
non-polar molecule

Key ideas

Equal arrows that point in opposite directions _____.

CO_2 is linear, so it is a _____.

Linear, trigonal planar and _____ shapes can cancel.

They cancel when all the outer atoms are _____.

Example

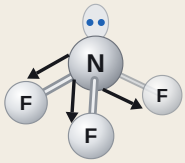
Carbon tetrafluoride, CF_4, is tetrahedral. All 4 outer atoms are fluorine. Is CF_4 polar? Say why.

Try it

Silicon tetrachloride, $SiCl_4$, is tetrahedral. All 4 outer atoms are chlorine. Is $SiCl_4$ polar? Say why.

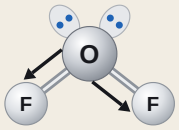
Slide 4 of 7 · Bond dipoles that never cancel

On the last slide, equal arrows pulled against each other and cancelled. A lone pair on the centre atom stops that. The molecule is lopsided.



nitrogen trifluoride, NF_3
trigonal pyramidal
the arrows all lean one way
polar molecule

The fluorine atoms are the δ− side.



oxygen difluoride, OF_2
angular
the arrows all lean one way
polar molecule

The fluorine atoms are the δ− side.

Key ideas

A _____ on the centre atom makes the molecule lopsided.

In NF_3, the 3 arrows do _____.

Trigonal pyramidal and _____ molecules with polar bonds are polar.

Example

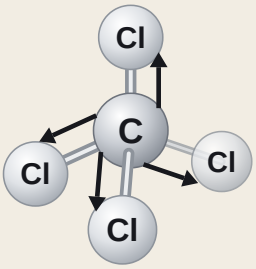
Ammonia, NH_3, is trigonal pyramidal. Is it polar? Say why.

Try it

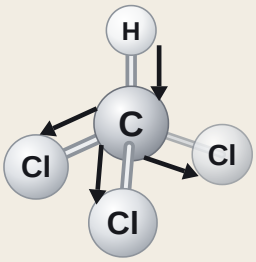
Water, H_2O, is angular. Is it polar? Say why.

Slide 5 of 7 · Different outer atoms

On slide 3, three shapes cancelled because they are symmetrical. "Symmetrical" means the same on every side. But the outer atoms must match too.



CCl_4 is non-polar.
Its 4 outer atoms are the same.



$CHCl_3$ is polar.
Its outer atoms differ.

Key ideas

_____ means the same on every side.

$CHCl_3$ is tetrahedral, but its arrows are _____.

So the arrows do not cancel, and $CHCl_3$ is _____.

A molecule made of only carbon and hydrogen is _____.

Example

Chloromethane, CH_3Cl, is tetrahedral. Is it polar? Say why.

Try it

Butane, C_4H_{10}, is made of only carbon and hydrogen. Is it polar? Say why.

Slide 6 of 7 · Method: how to decide whether a molecule is polar

You have now judged nine molecules. Each time you did the same four things. Here they are as steps.

1. **Find** the shape around the centre atom.
2. **Draw** a bond dipole on each polar bond.
3. **Ask** if the arrows cancel.
4. **State** polar or non-polar, with the reason.



Check: arrows cancel with matching outer atoms and no lone pair.

Used again in: lessons A11 and A12

Key ideas

Step 1: find the _____.

Step 2: draw the bond dipole _____.

Step 3: ask if the arrows _____.

Step 4: write the _____: polar or non-polar.

Example

Use the four steps on phosphorus trichloride, PCl_3. It has 1 lone pair on phosphorus.

Try it

Use the four steps on carbon tetrabromide, CBr_4. It has no lone pairs on carbon.

Slide 7 of 7 · Sort a set

Now use the four steps on six molecules. Decide each one before you look at the last column.

Molecule	Shape	Cancel?	Molecule is
SiH_4	tetrahedral	yes	non-polar
NF_3	trigonal pyramidal	no	polar
SiI_4	tetrahedral	yes	non-polar
OF_2	angular	no	polar
CH_2Cl_2	tetrahedral	no	polar
HCN	linear	no	polar

Key ideas

SiH_4 and SiI_4 are _____, so they are non-polar.

NF_3 and OF_2 have _____ on the centre atom, so they are polar.

CH_2Cl_2 and HCN have outer atoms that _____, so they are polar.

Example

Nitrogen trichloride, NCl_3, has 3 bonds and 1 lone pair on nitrogen. Is it polar? Say why.

Try it

Silicon tetrafluoride, SiF_4, has 4 bonds and no lone pairs on silicon. Is it polar? Say why.