Higher Chemistry: Unit 1 - Chemical Changes and Structure

Part B – Bonding, Structure and Properties

Lesson 3 – Polarity in Molecules

Learning Outcomes

By the end of this lesson you should know:

1. It is possible to detect polar bonds within a molecule by looking at the electronegativities of the elements present.

2. Whether a molecule has an overall polar or non-polar structure can be determined by the shape of the molecule.

Success Criteria

You will have been successful in this lesson if you:

1. Watch Ms Hastie's screencast of today's lesson
2. Read and learn the material given
3. Watch the links provided
4. Complete Exercise 1.7 and check your answers.

There is also a further reading section to help you gain more depth of understanding for this section.

MS Teams will be monitored throughout the week by a chemistry teacher. If you need help or clarification with either the task or the content of the lesson, just ask.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

- Higher Chemistry – Polarity and the bonding continuum
- National 5 chemistry – Shapes of molecules
- Data booklet https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Introduction - You don't need to write this part down, just read it, or watch Ms Hastie's lesson below…

WATCH – Ms Hastie's screencast of this lesson: Polarity in Molecules Screencast

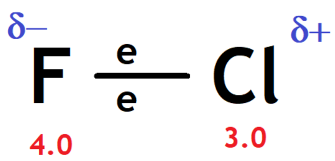
From the last lesson, we learned that covalent bonds can either be:

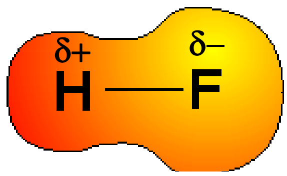
- **Non-Polar** (between atoms with the same electronegativity)

or

- **Polar** (between atoms with different electronegativities)

We also learned that the presence of a polar covalent bond causes a shift in the distribution of the electrons around the bond, causing one end of the bond to be slightly more negative and the other end to be slightly more positive:



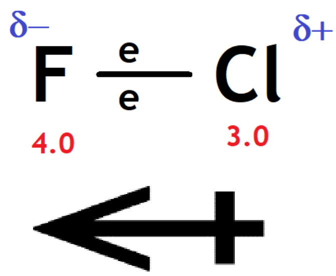


The examples given above are diatomic molecules, ie, containing only two atoms. In diatomic molecules, there are no other charges or atoms involved and therefore we can say that the molecule has **"overall polarity"**. In other words, one side of the molecule is slightly positive and the other side is slightly negative.

This can also be referred to as a **"permanent dipole"** which emphasises that one side is always slightly positive and the other always slightly negative.

You may come across this symbol 

This can be used to represent the direction of polarity in a molecule. The arrow points towards the side of the molecule with the more negative charge. (The other end of the arrow is at the side of the more positive side, hence the + sign)



For molecules containing more than two atoms, we have to take into consideration all polar bonds within the molecule and the shape of the molecule to determine whether it has a permanent dipole, ie an overall polar structure.

The overall polarity of a molecule influences how molecules interact with one another, their intermolecular forces. We will learn about this in much more detail in the next set of lessons.

Notes - Below is the summary you should write/ save / print a stick into your notes

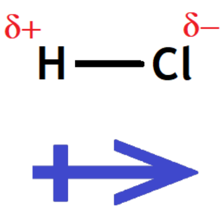
Types of covalent molecules

Covalent molecules can be divided into two groups:

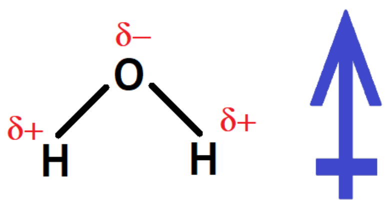
- POLAR MOLECULES - Those with overall polarity
- NON-POLAR MOLECULES – Those with no overall polarity

Polar molecules

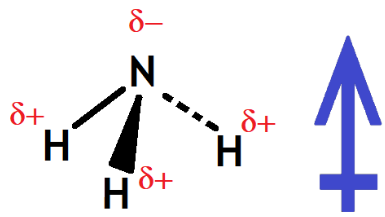
The molecules below contain polar bonds **AND** have overall **polar covalent structures**:



hydrogen chloride, HCl
(linear)



water, H_2O
(angular)



ammonia, NH_4
(trigonal pyramidal)

In each of these molecules, one side of the molecule is slightly positive and the other side is slightly negative. The arrow points to the negative side.

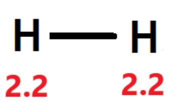
This is called a permanent dipole.

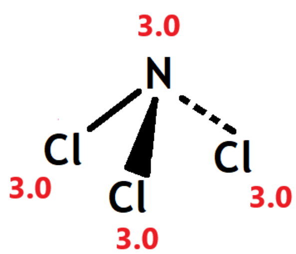
Non - Polar molecules

There are two ways that a molecule can have an overall non-polar structure:

1. Contains non-polar bonds

   If a molecule contains only non-polar bonds (ie only contains elements with the same electronegativity) then there is no overall polarity in the molecule. Two examples are below:

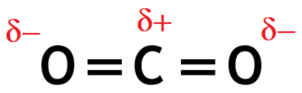




2. Contains polar bonds – but has an overall non-polar structure.

If a molecule contains polar bonds, the spatial arrangement of these bonds determines whether a molecule has an overall polarity.

Carbon dioxide, for example contains polar bonds between carbon and oxygen but its structure is linear, and therefore both ends of the molecule have slight negative charges.



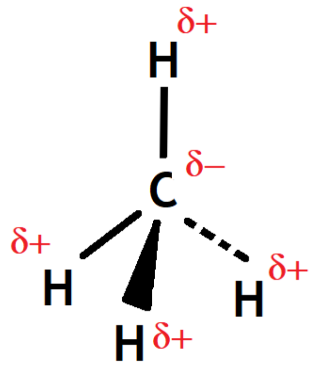
carbon dioxide, CO_2
(linear)

This is a non-polar molecule.

Methane, CH_4, contains polar bonds between carbon and hydrogen but its structure is tetrahedral and therefore the positive charges are on the 'outside'.

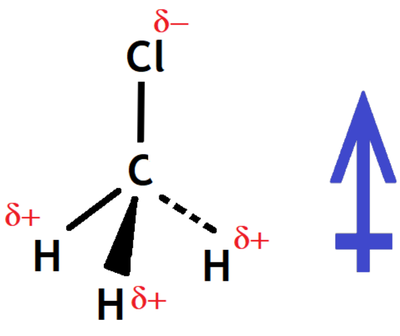
All hydrocarbon molecule are non-polar.

This is also a non-polar molecule.



methane, CH_4
(tetrahedral)

Tetrahedral structure are usually non-polar but there are a few exceptions. For example, if one of the hydrogen atoms in methane was replaced by chlorine, which is much more electronegative, it would give an uneven structure.



chloromethane

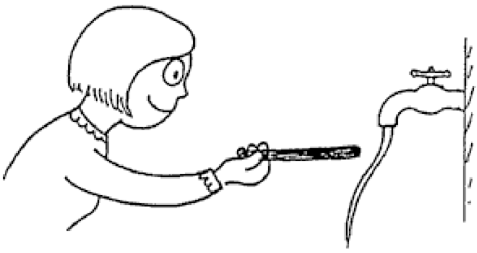
This is a polar molecule.

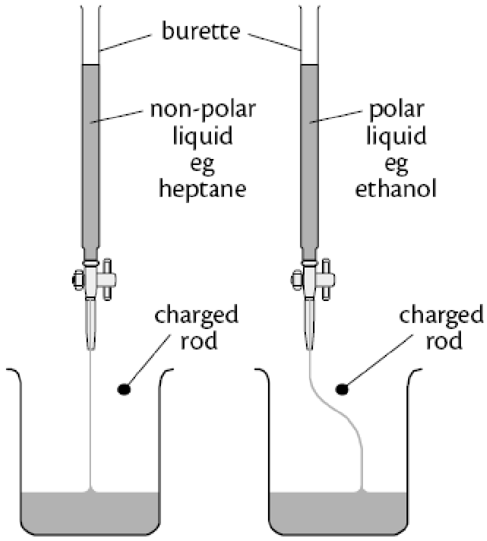
Experimenting with Polarity

WATCH – YOUTUBE – polarity experiment https://youtu.be/VhWQ-r1LYXY

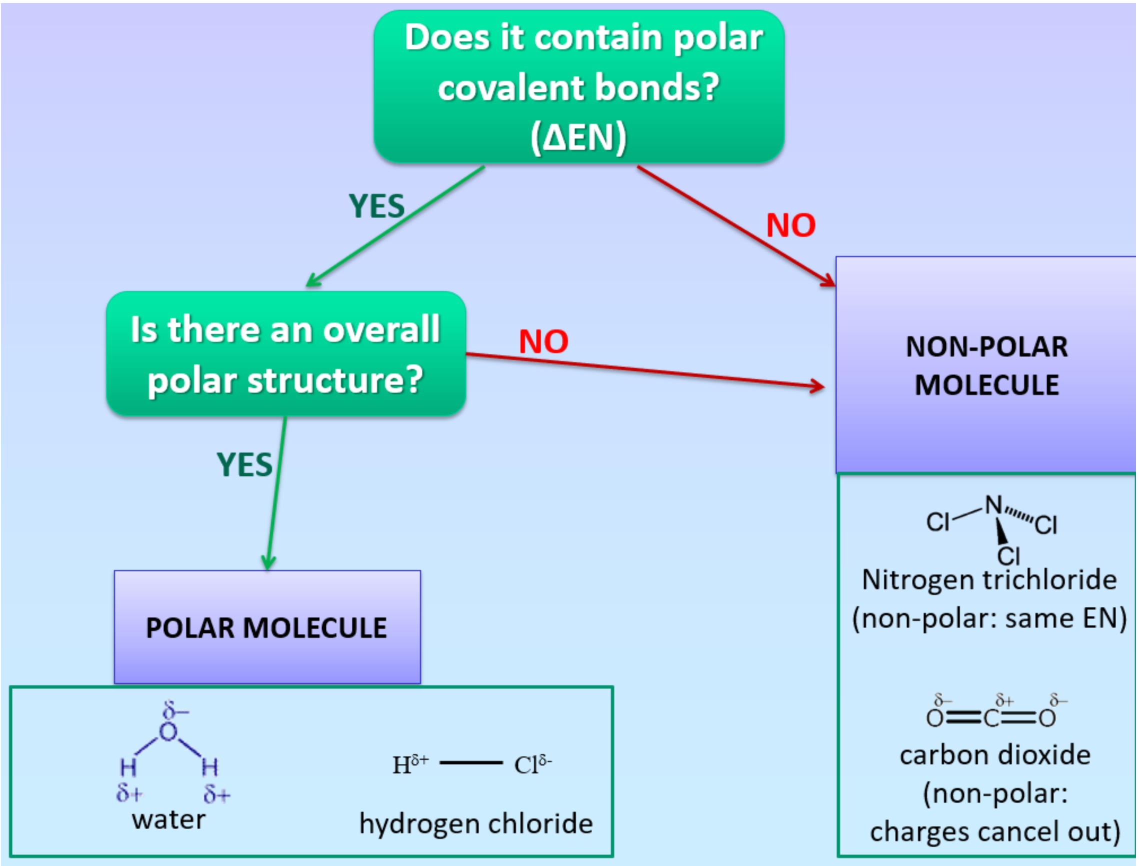
(You can try this experiment at home, with a very slow running tap and a comb, ruler or balloon that has been rubbed by a cloth or in your hair)

Polar molecules are attracted to a charged rod but non-polar molecules are not.





SUMMARY



Learning Outcomes

You should now know:

1. A molecule is described as polar if it has a permanent dipole.
2. The spatial arrangement of polar covalent bonds can result in a molecule being polar or non-polar.

Further Reading

To learn more about the bonding continuum. Follow the links below:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zt9887h

Read page 8

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

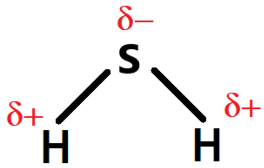
Select any teacher → revision material → CfE Higher → Structure and Bonding

Questions

Complete Exercise 1.7 and check your answers

Exercise 1.7 – Polarity in molecules

1. Hydrogen sulfide contains polar bonds and has an overall polar structure. It can be draw as follows:



POLAR

For each of the molecules below, draw the molecule out as above, showing the polarity of each bond, where appropriate, and state whether the molecule is polar or non-polar.

(a) Hydrogen phosphide, PH_3

(b) Iodine, I_2

(c) Hydrogen bromide, HBr

(d) Carbon tetrafluoride, CF_4

(e) Nitrogen trifluoride, NF_3

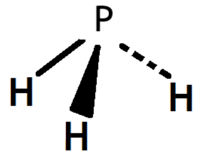
2. The molecule carbon tetrachloride contains polar bonds. However, the overall structure of the molecule is described as being non-polar.

Explain this apparent anomaly.

3. Both hydrogen molecules and fluorine molecules are non-polar while molecules of hydrogen fluoride are polar.

Explain this statement.

Exercise 1.7 – ANSWERS

1. (a) 

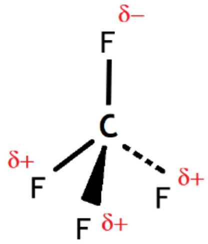
NON-POLAR (same electronegativities)

(b) 

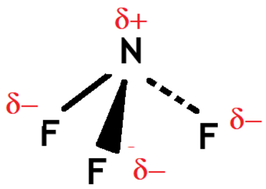
NON-POLAR (same electronegativity)

(c) 

POLAR

(d) 

NON-POLAR (non-polar shape)

(e) 

POLAR

2. *Carbon tetrachloride has polar bonds, however, the tetrahedral shape of the molecule results in a non-polar structure.*

3. *Hydrogen molecules and fluorine molecules are both non-polar because they are diatomic and there is no difference in electronegativity between two H atoms and two F atoms. However, a molecule of hydrogen fluoride H-F is polar because there is a difference in electronegativity between the H atom (2.2) and the F atom (4.0).*