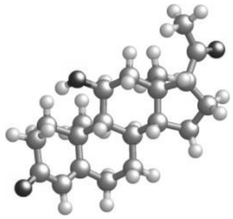

Chem!stry

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Class: ………………

Date: …… / …… / ……

<u>Electronegativity and Bond Polarity</u>

Electronegativity is a measure of the relative tendency of an atom to *attract a bonding pair of electrons*. The chemist Linus Pauling assigned electronegativity values to the chemical elements on an arbitrary scale from 0 – 4, 0 being the least electronegative and 4 the most electronegative. The electronegativity values of the first 36 chemical elements are given in the Periodic Table below:

Period	1	2	Group										3	4	5	6	7	8
1	**H** 2.1																	**He** –
2	**Li** 1.0	**Be** 1.5											**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0	**Ne** –
3	**Na** 0.9	**Mg** 1.2											**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0	**Ar** –
4	**K** 0.8	**Ca** 1.0	**Sc** 1.3	**Ti** 1.5	**V** 1.6	**Cr** 1.6	**Mn** 1.5	**Fe** 1.8	**Co** 1.8	**Ni** 1.8	**Cu** 1.9	**Zn** 1.6	**Ga** 1.6	**Ge** 1.8	**As** 2.0	**Se** 2.4	**Br** 2.8	**Kr** –

Question 1:

Why are no electronegativity values assigned to the Nobel Gases in Group 8?

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Question 2:

How do the electronegativity values of the chemical elements change *across a Period*? Use your knowledge of atomic structure to explain this trend.

………

………

Question 3:

How do the electronegativity values of the chemical elements change *down a Group*? Use your knowledge of atomic structure to explain this trend.

………

………

So, why is electronegativity important? A knowledge of electronegativity allows chemists to explain the existence of *polar bonds* in certain covalent compounds.

For example, consider a molecule of the compound *hydrogen fluoride*. In this molecule, an atom of hydrogen (electronegativity value of 2.1) is covalently bonded to an atom of fluorine (electronegativity value of 4.0):

$$2.1\ \mathrm{H{-}F}\ 4.0$$

The fluorine atom is much more electronegative than the hydrogen atom and so has a greater tendency to attract the pair of bonding electrons that are shared between the two atoms. Because the pair of negatively charged bonding electrons are closer to the fluorine atom than to the hydrogen atom, the *fluorine atom* gains a permanent *slight negative charge* (written δ–, pronounced *delta negative*) while the *hydrogen atom* gains a permanent *slight positive charge* (written δ+, pronounced *delta positive*):

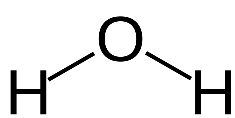
$$^{\delta+}\mathrm{H{-}F}^{\delta-}$$

Note: As a general rule, bond polarity will only be significant if there is a difference of *0.7 or more* between the electronegativity values of the two elements that are covalently bonded together.

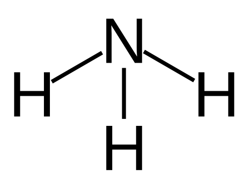
Question 4:

By referring to the electronegativity values given on page 1, indicate which bonds in the following molecules are polar by writing δ+ and δ– next to the appropriate atoms:

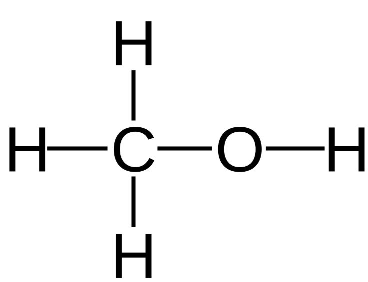
a) Water



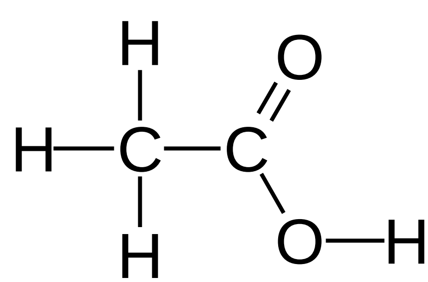
b) Ammonia



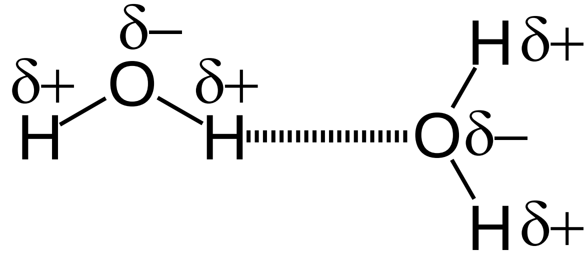
c) Methanol



d) Ethanoic acid



So, why is bond polarity important? You may have noticed that polar bonds tend to occur when a *hydrogen atom* is covalently bonded to an atom of a more electronegative element, such as nitrogen, oxygen or fluorine. The permanently charged regions of this polar bond will attract towards oppositely charged regions of a second polar bond, forming a special intermolecular force of attraction known as a *hydrogen bond*. Hydrogen bonds are normally represented by a dashed line drawn between the hydrogen atom of one polar bond and the nitrogen / oxygen / fluorine of the second polar bond. For example, the diagram below shows a hydrogen bond between two water molecules:



Hydrogen bonding explains why water is a liquid at room temperature and pressure as opposed to being a gas. Hydrogen bonding is also extremely important in determining the shapes of complex biological molecules, such as proteins and DNA.

Question 5:

Draw a molecule of methanol and at least one molecule of water. Use δ+ and δ– to indicate the bond polarity within the molecules and then draw dashed lines to clearly show any hydrogen bonds that might exist between them.

More to explore – some final questions to provoke further thinking:

Question 1:

Consider the electronegativity values of sodium and chlorine. Can *ionic bonds* be considered as extreme versions of *polar covalent bonds*? Justify your answer.

Question 2:

Ethanoic acid can *dimerise*, *i.e.* two molecules of ethanoic acid can hydrogen bond together to form a discrete pair. Draw a clearly labelled diagram to explain how this is possible.