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Worksheet #8: Polarity and Electronegativity

When atoms share valence electrons they do not always share them equally. Frequently one atom has a stronger attraction for the electrons than the other atom does. This uneven attraction causes the electrons to be held closer to one end of the bond than the other; we say this makes one end of the bond slightly positive and the other end of the bond slightly negative. A covalent bond with uneven sharing of the electrons is called a polar covalent bond. A bond in which the electrons are shared equally is called a nonpolar covalent bond.

1. Define the following terms:

- polar covalent
- nonpolar covalent

Electronegativity is a measure of the ability of an atom of an element to attract electrons to itself. Put another way, electronegativity is a measure of the force of attraction that exists between an atom and a shared pair of electrons in a covalent bond. Linus Pauling developed a scale of electronegativities that run from a low of 0.7 for several metals in Group 1 to a high of 4.0 for fluorine.

The table below gives Pauling Values for Electronegativity:

H 2.1																			He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0		Ne	
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0		Ar	
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	
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5		Xe	
Cs 0.7	Ba 0.9	La-Lu 1.1-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2		Rn	
Fr 0.7	Ra 0.9	Ac-Lr 1.1-																	

We use electronegativity values when we discuss bond polarity. If two atoms sharing a pair of electrons have equal values for electronegativity the bond is clearly nonpolar. As the difference in electronegativity increases the polarity of the bond increases, and if the difference in electronegativity is very large the bond is ionic.

- What is electronegativity?
- Sodium chloride (NaCl) is an example of an ionic bond. What is the difference in electronegativity between sodium and chlorine?
- Nitrogen dioxide (NO₂) is an example of a covalent bond. What is the difference in electronegativity between nitrogen and oxygen?

Worksheet 8-1

Name KEY

Periodic Trends

Period

- Discuss the importance of Mendeleev's periodic law.
When elements are arranged by increasing number of protons (atomic number), there are repeating patterns of chemical and physical properties.
- Identify each element as a metal, metalloid, or nonmetal.
 - Fluorine Nonmetal
 - Germanium Metalloid
 - zinc Metal
 - phosphorous Nonmetal
 - lithium Metal
- Give two examples of elements for each category.
 - noble gases He, Ne, Ar, Kr, Xe, Rn, 118
 - halogens F, Cl, Br, I, At, 117
 - alkali metals Li, Na, K, Rb, Cs, Fr
 - alkaline earth metals Be, Mg, Ca, Sr, Ba, Ra
- What trend in atomic radius do you see as you go down a group/family on the periodic table? What causes this trend? Atomic radii INCREASE going down a group due to added energy levels and increases shielding effects.
- What trend in atomic radius do you see as you go across a period/row on the periodic table? What causes this trend? Atomic radii DECREASE going across a period due to added energy levels and increases shielding effects.
- Circle the atom in each pair that has the largest atomic radius.
 - Al B
 - S O
 - Br Cl
 - Na Al
 - O F
 - Mg Ca
- Define ionization energy.
The amount of energy required to remove a valence electron.
- What trend in ionization energy do you see as you go down a group/family on the periodic table? What causes this trend? Ionization energy DECREASES as you go down a group, as the atomic radius increases. This is due to greater shielding effects.

ELECTRONEGATIVITY

Use the diagrams and the definitions in the sheet. The electronegativity difference (measured in eV) is calculated according to the formula: $\Delta EN = EN(A) - EN(B)$. Use the electronegativity values in the table below to calculate the electronegativity difference for each bond.

Electronegativity (eV)	Electronegativity (eV)	Electronegativity (eV)
1.0	2.0	3.0
4.0	5.0	6.0

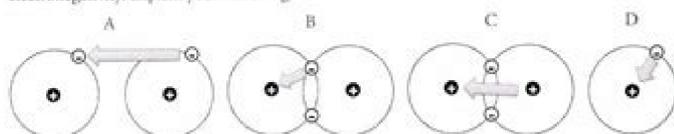
Bond	Lewis structure	Electronegativity difference (eV)	EN of bond	Polarity or ionic character (charge)	Electronegativity difference (eV) between the atoms (EN(A) - EN(B))	Polarity of molecule
1. H-H	$H \equiv H$	0	0	non-polar	0	non-polar
2. H-Cl	$H-Cl$	1	1	slightly polar	1	slightly polar
3. H-F	$H-F$	2	2	moderately polar	2	moderately polar
4. C-Cl	$C-Cl$	1	1	slightly polar	1	slightly polar
5. H ₂ O	H_2O	1	1	slightly polar	1	slightly polar
6. H ₂ S	H_2S	0	0	non-polar	0	non-polar
7. HCl ₂	HCl_2	1	1	slightly polar	1	slightly polar
8. CFC ₂	CFC_2	1	1	slightly polar	1	slightly polar
9. SO_2 (bond angles: 119° and 119°)	SO_2	2	2	moderately polar	2	moderately polar
10. CO_2	CO_2	0	0	non-polar	0	non-polar

Key P.T.

Read This!

Electronegativity is a measure of the ability of an atom's nucleus to attract electrons from a different atom within a covalent bond. A higher electronegativity value correlates to a stronger pull on the electrons in a bond. This value is only theoretical. It cannot be directly measured in the lab.

12. Using the definition stated in the *Read This!* box above, select the best visual representation for electronegativity. Explain your reasoning.



13. Locate the electronegativity values in Model 1.

- a. What is the trend in electronegativity going down a group in Model 1?

Electronegativity decreases as you go down a group (vertical column).

- b. Explain the existence of the trend described in part a in terms of atomic structure and Coulombic attraction.

The ability to attract electrons is based upon attractive force. The greater the distance between the nucleus and valence electrons, the less the attractive force. Less force means a lower electronegativity.

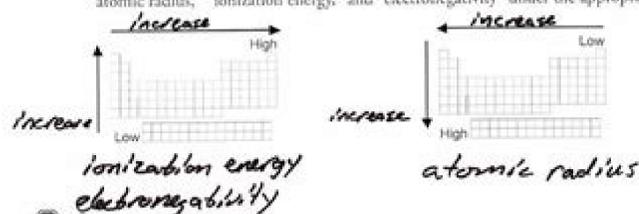
- c. What is the trend in electronegativity going across a period in Model 1?

Electronegativity increases from left to right across a period (horizontal row).

- d. Explain the existence of the trend described in part c in terms of atomic structure and Coulombic attraction.

The greater the number protons in an atom, in a particular period, the greater the attractive force between the nucleus and valence electrons. The greater attractive force means a higher electronegativity.

14. The two diagrams below can summarize each of the three trends discussed in this activity. Write "atomic radius," "ionization energy," and "electronegativity" under the appropriate diagram.



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