CHEMISTRY INVESTIGATIONS ___ & ____ NAME ______________________________ HOUR ___

# DIATOMIC AND POLYATOMIC COVALENT MOLECULES

PURPOSE: to construct and examine ball and stick models of some molecules of covalent substances in order to show how their shapes and structures (arrangement of atoms) determine their polarities; to draw and examine different types of notations used for representing these molecules.

INTRODUCTION: Covalent bonding occurs when one or more pairs of electrons are shared between two atoms. The sharing of the electrons may be even or uneven. Even sharing of electrons produces a PURE COVALENT BOND between atoms of the same element or a NONPOLAR COVALENT BOND between atoms of different elements.

If the two bonding atoms are different, any pairs of electrons are shared unevenly or unequally. This produces a covalent bond which is polar to a greater or lesser degree. ELECTRONEGATIVITY is the measure of an atom's attraction for a shared pair of electrons. The amount of difference in two atoms' electronegativities determines how polar the bond is. If the electronegativity difference between the atoms of two elements is 0.4 or less, the bond is usually considered essentially nonpolar. If the electronegativity difference between the atoms of the two elements is in the interval of 0.5 to 1.6, the bond is polar. Such a polar bond is called a POLAR COVALENT BOND.

## DETERMINING BOND POLARITY:

Since covalent bonds may be either polar or nonpolar, molecules of covalent substances may also be either polar or nonpolar. In order to determine bond polarity, it is necessary to know the electronegativities of the elements forming the bond.

Using the table on the back of this sheet you can find the electronegativities of the atoms involved in forming the bond. The difference in the electronegativities is found by subtracting the smaller electronegativity from the larger one, no matter how many atoms of each element are involved in the compound. DIFFERENCES are ONLY found BETWEEN ATOMS that ACTUALLY BOND TO EACH OTHER in the compound. Using the difference you can determine if the bond is polar or nonpolar. If the electronegativity difference is 0.4 or less, the bond is nonpolar. If the difference is in the range 0.5 to 1.6, the bond is polar.

## DETERMINING THE POLARITY OF A MOLECULE:

It is easiest to determine the polarity of a diatomic molecule. Its polarity is the same as the bond polarity. Diatomic molecules with nonpolar bonding are nonpolar molecules. Diatomic molecules with polar bonding are polar molecules.

Molecules which contain more than two atoms may be either nonpolar or polar, depending both on the bond polarity and the bond arrangement. Any polyatomic molecule with ALL nonpolar bonds must be nonpolar. A polyatomic molecule which contains one or more polar bonds is usually polar, but symmetry of polar bonds may produce a nonpolar molecules. This occurs when polar bonds are arranged symmetrically (evenly) around a central atom. If the arrangement of the polar bonds is unsymmetrical (uneven), the molecule is polar.

## SHAPES OF MOLECULES:

(1) linear--all atoms are arranged in a straight line; this is the only possible arrangement for diatomic molecules
(2) bent--atoms are in a line, but not in a STRAIGHT line
(3) pyramidal--atoms are arranged in a 3-cornered pyramid
(4) tetrahedral--four atoms are distributed evenly around a center atom

## COLOR CODE FOR ATOMS IN THE BALL-AND-STICK MODEL KIT:

| | |
|---|---|
| hydrogen = yellow | oxygen = red |
| nitrogen = light blue | carbon = black |
| iodine = purple | chlorine = green |
| bromine = orange | sulfur = brown |

## DIATOMIC COVALENT MOLECULES

### PROCEDURE

1. Draw the electron dot formula, structural formula, and orbital notation for each molecule.
2. Indicate the type of bond (single, double, or triple) present in each molecule.
3. List the electronegativities of each of the elements present in the molecule.
4. Find the difference in the electronegativity of the atoms bonded together (it is zero if both of the atoms are of the same element).
5. On the basis of the electronegativity difference, determine the bond polarity (polar or nonpolar).
6. Construct models of the molecules with the kits provided. If the bond is a single bond, use a short wooden peg for the shared electron pair. If the bond is a double or triple bond, use a spring for each shared electron pair.
7. Look at the models of the molecule and determine their shapes and polarities.

## POLYATOMIC COVALENT MOLECULES

### PROCEDURE

1. Draw the electron dot formula and the structural formula for each molecule.
2. For the types of bonds present, show the atoms bonded together using structural formula notation FOR EACH *DIFFERENT* TYPE OF BOND. For example, $H_2O$ contains two H—O (or O—H) bonds.
3. List the electronegativities of each of the elements present in the molecule.
4. Find the electronegativity difference BETWEEN ATOMS THAT ARE BONDED TOGETHER.
5. Tell if the bond is polar or nonpolar. There are two different bonds in the last two molecules, so you should tell the polarity of each.
6. Construct the model of each molecule. Look at it and determine its shape and polarity.

PERIODIC TABLE OF ELECTRONEGATIVITIES

| I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1 H 1 | | | | | | | | | | | | | | | | | He 2 |
| 1.0 Li 3 | 1.5 Be 4 | | | | | | | | | | | 2.0 B 5 | 2.5 C 6 | 3.0 N 7 | 3.5 O 8 | 4.0 F 9 | Ne 10 |
| 0.9 Na 11 | 1.2 Mg 12 | | | | | | | | | | | 1.5 Al 13 | 1.8 Si 14 | 2.1 P 15 | 2.5 S 16 | 3.0 Cl 17 | Ar 18 |
| 0.8 K 19 | 1.0 Ca 20 | 1.3 Sc 21 | 1.5 Ti 22 | 1.6 V 23 | 1.6 Cr 24 | 1.5 Mn 25 | 1.8 Fe 26 | 1.8 Co 27 | 1.8 Ni 28 | 1.9 Cu 29 | 1.6 Zn 30 | 1.6 Ga 31 | 1.8 Ge 32 | 2.0 As 33 | 2.4 Se 34 | 2.8 Br 35 | 3.0 Kr 36 |
| 0.8 Rb 37 | 1.0 Sr 38 | 1.2 Y 39 | 1.4 Zr 40 | 1.6 Nb 41 | 1.8 Mo 42 | 1.9 Tc 43 | 2.2 Ru 44 | 2.2 Rh 45 | 2.2 Pd 46 | 1.9 Ag 47 | 1.7 Cd 48 | 1.7 In 49 | 1.8 Sn 50 | 1.9 Sb 51 | 2.1 Te 52 | 2.5 I 53 | 2.6 Xe 54 |
| 0.7 Cs 55 | 0.9 Ba 56 | 1.2 Lu 71 | 1.3 Hf 72 | 1.5 Ta 73 | 1.7 W 74 | 1.9 Re 75 | 2.2 Os 76 | 2.2 Ir 77 | 2.2 Pt 78 | 2.4 Au 79 | 1.9 Hg 80 | 1.8 Tl 81 | 1.8 Pb 82 | 1.9 Bi 83 | 2.0 Po 84 | 2.2 At 85 | 2.4 Rn 86 |

Chemisrty Investigation ______

# POLYATOMIC COVALENT MOLECULES

Name ____________________ Hour ______

| MOLECULAR FORMULA | ELECTRON DOT FORMULA | STRUCTURAL FORMULA | BOND TYPES (Show Structure) | ELECTRONEGATIVITY | | BOND POLARITY (polar or nonpolar) | SHAPE OF MOLECULE | POLARITY OF MOLECULE (polar or nonpolar) |
|---|---|---|---|---|---|---|---|---|
| | | | | Elements | Difference | | | |
| $H_2O$ | | | | | | | | |
| $H_2S$ | | | | | | | | |
| $CO_2$ | | | | | | | | |
| $NH_3$ | | | | | | | | |
| $CH_4$ | | | | | | | | |
| $CCl_4$ | | | | | | | | |
| $CH_3Cl$ | | | | | | | | |
| $H_2O_2$ | | | | | | | | |

Chemistry Investigation ______ **DIATOMIC COVALENT MOLECULES** Name ____________ Hour ______

| MOLECULAR FORMULA | ELECTRON DOT FORMULA | STRUCTURAL FORMULA | ORBITAL NOTATION | BOND TYPE (Single, Double, Triple) | ELECTRO-NEGATIVITY Element ↓ | Difference ↓ | BOND POLARITY (p or np) | SHAPE OF MOLECULE | POLARITY OF MOLECULE (p or np) |
|---|---|---|---|---|---|---|---|---|---|
| HF | H:F: | H–F | F ⊗ 1s ⊗ 2s ⊗⊗⊘ 2p ⊘ 1s H | S | H=2.1 F=4.0 | 1.9 | P | Linear | P |
| $H_2$ | | | | | | | | | |
| $Cl_2$ | | | | | | | | | |
| $O_2$ | | | | | | | | | |
| $N_2$ | | | | | | | | | |
| $Br_2$ | | | | | | | | | |
| HCl | | | | | | | | | |
| HBr | | | | | | | | | |
| HI | | | | | | | | | |
| BrCl | | | | | | | | | |