Title: Molecular Model Lab

Purpose: In this experiment, you will build models of some compounds, predict each compounds shape, determine if the molecule is polar or non-polar, and state what type of attractive force the compound has

Pre – Lab Discussion:

The polar nature of a molecular compound determines many of the physical properties of that compound. Polar molecules have higher boiling and melting points than nonpolar molecules of approximately same size (mass). The higher boiling and melting points are due to the presence of stronger intermolecular attractive forces between the polar molecules than is found between nonpolar molecules. The stronger intermolecular attractive forces are caused by the shift of the shared electrons in the bonds toward the more electronegative element of the molecule. This shift of the electrons causes a dipole with a partially positive and partially negative ends to form within the polar molecule. The oppositely partially charged ends attract each other forming the strong attractive force between the molecules. This attractive force is called a dipole attraction. In polar molecules containing hydrogen attached to a small, highly electronegative atom, such as fluorine, oxygen or nitrogen, an even stronger dipole attraction occurs called hydrogen bonding.

The attractive force between nonpolar molecules is a very weak force called van der Waal's force or London Dispersion Force. The van der Waal's force is caused by the moving electrons in the molecule, which cause a very weak temporary dipole in the molecule. Two factors, the size of the molecule and the distance between the molecules, affect the strength of the van der Waal's force. The closer the molecules are to each other, the stronger the van der Waal's force. The larger the size of the molecule is, the greater the force. Since larger molecules contain more moving electrons to cause the van der Waal's force, the larger molecule, the larger the van der Waal's force will be.

The electronegativity difference (END) between the bonding elements can be used to determine the polarity of the bonds within the molecule. If the END is less than 0.3, the bond is nonpolar. If the END is between 0.3 and 1.7, the bond will be polar. However, the symmetry of the molecule must be considered in determining if the whole molecule is polar or nonpolar. A nonpolar molecule will have a symmetrical arrangement of charge around a central atom. A polar molecule will have an asymmetrical arrangement of the charge around the central atom (one with the most bonds). Even if a molecule contains polar bonds, if these bonds are symmetrically arranged around the central atom the molecule will be nonpolar.

Materials: Reference Tables, Molecular Model building kit, colored pencils

Procedure: Construct models of each of the formulas given on the worksheet. To construct these models use the appropriate colored round pieces for the atoms; 1 plastic straw for single bonds; and two or three straws to represent double or triple bonds, respectively. YOU MUST USE THE CORRECT NUMBER OF ATOMS AS INDICATED BY THE FORMULA AND THE NUMBER OF BONDS LISTED IN THE KEY FOR THAT ELEMENT.

On REFERENCE TABLE S, Look up and record the electronegativity (EN) for the elements below.

COLOR	ELEMENT	(EN)	# OF BONDS TO FORM
BLACK	CARBON	____	4 BONDS
RED	OXYGEN	____	2 BONDS
WHITE	HYDROGEN	____	1 BOND
GREEN	CHLORINE	____	1 BOND
BLUE	NITROGEN	____	3 BONDS

For each formula, complete the information on the worksheet:

1. MOLECULA MODEL: SKETCH THE MODEL THAT YOU HAVE CONSTRUCTED. COLOR CODE & LABEL THE ENDS WITH THE ELEMENT SYMBOL.

2. STRUCTURAL FORMULA- USE THE ELEMENT SYMBOLS TO REPRESENT THE ATOM, DRAW ONE LINE TO REPRESENT EACH BOND BETWEEN ATOMS. THE SHAPE SHOULD BE THE SAME AS THE BALL & STICK MODEL.

3. ELECTRON-DOT DIAGRAM- REPLACE EACH LINE IN THE STRUCTURAL FORMULA WITH A PAIR OF ELECTRONS. USE "o" TO REPRESENT ONE ELEMENT'S ELECTRONS AND x TO REPRESENT OTHER ELEMENT'S ELECTRONS. EACH PAIR OF "xo" (DOTS), REPRESENTS ONE BOND (line). PLACE ANY UNSHARED PAIR OF ELECTRONS SYMMETRICALLY AROUND EACH ELEMENT. EACH ELEMENT SHOULD HAVE FULL "OCTET" (8 dots) OR 4 PAIRS OF ELECTRONS (EXCEPT HYDROGEN-ONLY 1 PAIR OF ELECTRONS).

4. POLARITY OF BONDS

TO DETERMINE POLARITY OF BONDS use the electronegativity difference (END) between the two atoms: END < 0.3 =NONPOLAR 0.3< END<1.7 = POLAR

5. DETERMINE IF THE MOLECLE IS SYMMETRICAL OR ASYMMETRICAL

6. POLARITY OF MOLECULE :
   a) ALL nonpolar bonds = nonpolar molecule
   b) polar bonds present:
      1 line of symmetry = polar
      2 or more lines of symmetry = nonpolar

7. ATTRACTIVE FORCE
   a) NONPOLAR MOLECULE = van der Waals Force
   b) POLAR MOLECULE
      (1) Regular dipole
      (2) H attached to N, O, F = hydrogen bonding

8. SHAPES OF MOLECULES- LINEAR; BENT; PYRAMIDAL; OR TETRAHEDRAL

Formula	Ball & Stick Sketch	Structural Formula	Electron Dot Diagram	END	Bonds: Polar or Nonpolar?	symmetry	Polarity of Molecule	Shape of Molecule	Attractive Force
H_2									
HCl									
N_2									
NH_3									
O_2									
H_2O									
CO_2									
CH_4									
$CHCl_3$									

ANALYSIS QUESTIONS: (Complete sentences)

1) What type of elements form molecules with covalent bonds?

2) Hydrogen, oxygen and nitrogen are all diatomic molecules. How many bonds are formed between the two atoms a) hydrogen b) oxygen c) nitrogen

3) What shape do all 2 atom molecules have?

4) What shape does methane, CH_4, have? What other molecule from the worksheet has the same shape?

5) Explain using two examples how to determine if a bond is polar or nonpolar.

6) Explain using two examples how to determine if a molecule is polar or nonpolar.

7) Why can a molecule contain polar bonds but be a nonpolar molecule?

8) How does the strength of the attractive force holding molecules of a substance together affect the melting and boiling point of that substance?

9) a) What attractive force holds molecules of CO_2 together?

b) What is the strength, weak or strong, of this attractive force?

10) a) What attractive force holds molecules of H_2O together?

b) What is the strength, weak or strong, of this attractive force?

11) Based on the polarity of the molecule and attractive forces, explain why CO_2 is a gas and H_2O is a liquid at room temperature.