COVALENT COMPOUNDS

Chemistry 332
**Unit 4 (Covalent Compounds)**
1. Write the electron dot structure (Lewis Dot Structure) for covalent compounds or ions.
2. Use electronegativity to determine the polarity of a bond or molecule.
3. Given the formula of a covalent compound, write its correct name; given the name of a covalent compound, write its formula.
4. Describe the attractive forces between ions, polar molecules, and nonpolar molecules.

**Unit 4 (Covalent Compounds)**
Covalent Bond, Octet Rule, Lewis Dot Structure/Intramolecular Bond, Intermolecular Force, Polar, Non-polar, Solubility
COVALENT COMPOUNDS

Covalent compounds are made from two non-metals and so don’t follow the normal ionic rules. You can tell if a compound is covalent because it has prefixes modifying the species names. These species tell you exactly how many atoms are in the covalent compound.

The prefixes are

1 = mono
2 = di
3 = tri
4 = tetra
5 = penta
6 = hexa
7 = hepta
8 = octa
9 = nona
10 = deca

All you have to do is write the species in the compound together, and add a subscript based on the numbers above:

nitrogen dioxide: NO₂
dinitrogen monoxide: N₂O

phosphorus pentachloride: PCl₅
sulfur hexafluoride: SF₆

diphosphorus pentoxide: P₂O₅

Most organic compounds that contain alcohol (R-OH) or carboxylic acid (R-COOH) functional groups will most likely be soluble due to the hydrogen bonding capabilities of those substances. Other covalent compounds tend to be insoluble in water.

Most organic and covalent compounds will not conduct electricity in water. The exception to this rule are organic acids (carboxylic acids).
Chemistry 332

Name ______________________

Covalent Naming

I. Name the following compounds.

1. N₂O₅ _________________________________

2. SeBr₆ _________________________________

3. CH₄ _________________________________

4. C₆H₆ _________________________________

5. PF₆ _________________________________

6. BF₃ _________________________________

7. P₂I₄ _________________________________

8. S₂Cl₃ _________________________________

9. NO₂ _________________________________

10. P₂O₅ _________________________________

11. OF₂ _________________________________

12. CO _________________________________

13. BrO₃ _________________________________

14. BN _________________________________

15. CBr₄ _________________________________
II. Please write the formulas for the following compounds.

1. Dihydrogen monoxide ________________________________________________
2. Phosphorus trihydride _____________________________________________
3. Dinitrogen trioxide _________________________________________________
4. Carbon tetrachloride ________________________________________________
5. Carbon dioxide ____________________________________________________
6. Trinitrogen tetroxide ________________________________________________
7. Dinitrogen monoxide ________________________________________________
8. Tetraphosphorus decaoxide _________________________________________
9. Selenium trioxide __________________________________________________
10. Iodine heptafluoride _______________________________________________
11. Sulfur hexafluoride ________________________________________________
12. Sulfur dichloride __________________________________________________
13. Disilicon hexabromide _____________________________________________
14. Dichlorine heptaoxide _____________________________________________
15. Pentaphosphorus deoxide __________________________________________
Covalent Compounds

1. Name the following compounds.
   - AsF₅
   - OF₂
   - TeF₄

   - CCl₄
   - CO
   - H₂Se

   - PH₃
   - SeO₂
   - PI₃

2. Write the formulas for the following compounds.
   - Disulfur dichloride
   - nitrogen trihydride

   - Silicon tetroxide
   - nitrogen dioxide

   - Arsenic tribromide
   - tetraphosphorus hexoxide

   - diphosphorus pentoxide
   - sulfur dioxide

   - carbon tetrabromide
   - disulfur pentoxide
### Modeling Lewis Dot Structures

**Directions:** Complete the missing information on the data table below. Construct a model for any compounds that have an asterisk (*) next to their name. The key below will designate the appropriate color for each element.

**Element**
- Hydrogen: white
- Carbon: black
- Oxygen/sulfur/selenium: red
- Nitrogen: blue
- Halogens: green (small)

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Formula</th>
<th>Valance Electrons</th>
<th># of Dashes</th>
<th>Lewis Dot Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>CO₂</td>
<td>C – 4 O - 12</td>
<td>8</td>
<td>Ọ = C = ᵒ</td>
</tr>
<tr>
<td>ammonia</td>
<td>NH₃</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>methane</td>
<td>CH₄</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>propane</td>
<td>C₃H₈</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydrochloric acid</td>
<td>HCl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ethane</td>
<td>C₂H₄</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbon tetrachloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bromine gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBr₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Lewis Dot Structures**
*(Side 2)*

**Directions:** Complete the data table below. It is not necessary to construct any models.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Valance Electrons</th>
<th># of Dashes</th>
<th>Lewis Dot Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCl₃</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SiS₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSiN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF₂Cl₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GeH₄</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSF₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SeCl₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AsF₃</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C₂Br₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂O</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH₂O</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF₄</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lewis Dot Structures Worksheet #1

Homework Problems

1. CO₂

2. H₂O

3. H₂CO

4. HI

5. NH₃

6. HCCH

7. CH₄

8. CH₂F₂

9. SeF₂

10. HCN
Name ____________________________

Lewis Dot Structures Worksheet #2

Homework Problems

1. HCl
2. C1CN

3. CS₂
4. H₂S

5. N₂
6. Br₂CCBr₂

7. NI₃
8. O₂

9. CF₄
10. H₃COH
Lewis (Electron) Dot Formulas – 5 Easy Rules

1. Determine Arrangement – Place the least electronegative atom in the center. The halogens and hydrogen can never be in the center.

2. Determine total number of valence electrons. Two electrons are represented by one dash.
   (add for negative ions, subtract for positive ions)

3. Attach central atom to surrounding atoms. Molecule should be symmetrical.

4. Distribute remaining electrons.

5. Use double or triple bonds if necessary. Hydrogen and the halogens can never have a double or triple bond.
<table>
<thead>
<tr>
<th></th>
<th>1A</th>
<th>2A</th>
<th>3A</th>
<th>4A</th>
<th>5A</th>
<th>6A</th>
<th>7A</th>
<th>8A</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>1.0</td>
<td>Be</td>
<td>2.0</td>
<td>B</td>
<td>2.5</td>
<td>C</td>
<td>3.0</td>
<td>N</td>
</tr>
<tr>
<td>Na</td>
<td>0.9</td>
<td>Mg</td>
<td>1.2</td>
<td>Al</td>
<td>1.5</td>
<td>Si</td>
<td>1.8</td>
<td>P</td>
</tr>
<tr>
<td>K</td>
<td>0.8</td>
<td>Ca</td>
<td>1.0</td>
<td>Ga</td>
<td>1.6</td>
<td>Ge</td>
<td>1.8</td>
<td>As</td>
</tr>
<tr>
<td>Rb</td>
<td>0.8</td>
<td>Sr</td>
<td>1.0</td>
<td>In</td>
<td>1.7</td>
<td>Sn</td>
<td>1.8</td>
<td>Sb</td>
</tr>
<tr>
<td>Cs</td>
<td>0.7</td>
<td>Ba</td>
<td>0.9</td>
<td>Tl</td>
<td>1.8</td>
<td>Pb</td>
<td>1.9</td>
<td>Bi</td>
</tr>
<tr>
<td>Fr</td>
<td>0.7</td>
<td>Ra</td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Differences in Electronegativity
Covalent Non-polar = 0 – 0.4
Covalent Polar = 0.5 and above
Ionic = Contains a metal
Polarity w/s

Given the molecules below, identify those which are polar and which are nonpolar. Then identify which ones form hydrogen bonds with like molecules.
Investigating Some Properties of Water

A water molecule is formed when two hydrogen atoms are bonded to a single oxygen atom. Because of the structures of the atoms involved, a bent molecule is formed.

The bond between each hydrogen and the oxygen atom is formed by the sharing of a pair of electrons. The electrons are not shared equally between the two atoms. The oxygen atom has greater attraction for the shared pair of electrons so it keeps them closer to itself. The unequal sharing causes the oxygen atom to have a partial negative charge (δ-) while the hydrogen atoms will have a partial positive charge (δ+).

Because the partially negative oxygen and partially positive hydrogen’s are arranged in a bent shape, the water molecule has a positive side and a negative side; it is called a polar molecule or dipole.

This polarity causes the water molecules to be attracted to each other. The positive side of one molecule is attracted to the negative side of another molecule.

This intermolecular attraction (shown by the lighter lines) is weaker than the covalent bonds which hold the hydrogen and oxygen atoms together in each molecule, but is strong enough to affect the properties of water.

In this lab you will investigate some properties of water by comparing water’s behavior to that of hexane in several situations. Hexane is a non polar molecule because of the very uniform arrangement of the atoms in the molecule.
Name ____________________________

Investigating Some Properties of Water PLW

1. Draw the molecular structure of water and label the partial charges of each element.

2. Why is the water molecule’s shape bent and not linear?

3. How does the shape of the water molecule determine its polarity?


5. Using class notes, describe intermolecular bonds.

6. Draw the structure of hexane and describe its polarity.
Name ___________________________

Water & Cyclohexane Lab Questions

Table 1: Rate of evaporation
Explain in detail why the drop of cyclohexane evaporated faster than the drop of water.

Table 2: Capillary action
Explain in detail why the water went further up the glass capillary tube than did cyclohexane.

Table 3: Surface Tension
Explain in detail why you were able to put more drops of water than cyclohexane on a penny.

Table 4: Wax Paper
Explain in detail why the water and cyclohexane behaved as they did on wax paper.
Table 5: Static Charge
Explain in detail why the water was bent by static charge but the cyclohexane wasn’t.

Table 6: Vortex
Explain in detail why the cyclohexane was easier to make a vortex in than water.

Table 7: Surface tension
Explain in detail why a paperclip can float on top of water but not on top of cyclohexane.
Lab- Covalent Solubility

Purpose- The purpose of this lab is to develop a series of solubility guidelines for covalent compounds.

Safety: Goggles and Aprons must be worn

Procedure-
1. Fill 7 test tubes ¾ full with tap water.
2. Using the small bottles provided, add 10 drops of each chemical to a test tube.
3. Put a stopper on each test tube and shake for 30 seconds.
4. Let the contents of the tube settle and examine each tube.
5. Make a determination if the substance dissolved in the water or not.
6. Record your results in the data table.
7. Dispose of the chemicals as instructed by your teacher.

Data-

<table>
<thead>
<tr>
<th>Substance</th>
<th>Dissolves in water?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td></td>
</tr>
<tr>
<td>Cyclohexane</td>
<td></td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td></td>
</tr>
<tr>
<td>Acetic acid</td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td></td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td></td>
</tr>
</tbody>
</table>

Explanation-

Come up with a guideline for the solubility of these compounds in water. You should complete the statements:

A substance will dissolve in water if…
Methanol

Cyclohexane

Ethyl acetate

Acetic Acid

Ethanol

Toluene

Ethylene glycol
### Intramolecular Bonds
(Bonds within a compound)

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Electronegativity Difference</th>
<th>Examples</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covalent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar</td>
<td></td>
<td>Electronegativity Difference is .5 or greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covalent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Polar</td>
<td></td>
<td>Electronegativity Difference is less than .5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Intermolecular Bonds
*(Bonds between two compounds)*

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Examples</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dipole-Dipole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispersion aka London Forces</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Evaporation and Intermolecular Attractions

In this experiment, Temperature Probes are placed in various liquids. Evaporation occurs when the probe is removed from the liquid’s container. This evaporation is an endothermic process that results in a temperature decrease. The magnitude of a temperature decrease is related to the strength of intermolecular forces of attraction. In this experiment, you will study temperature changes caused by the evaporation of several liquids and relate the temperature changes to the strength of intermolecular forces of attraction. You will examine the molecular structures for the presence and relative strength of two intermolecular forces—hydrogen bonding and dispersion forces.

PRE-LAB SET UP

Obtain six test tubes, each with a different chemical. Set #1 should contain: Ethylene Glycol, Ethanol, and Cyclohexane. Set #2 should contain: Methanol, water, and Acetone. You should also have a Vernier logger-pro green box with three different temperature probes attached to it. Be sure you know which temperature probe is plugged into which slot.

CHEMICAL STRUCTURES

The chemical structures of the six chemicals to be used in this experiment are shown below.
PROCEDURE

1. Obtain and wear goggles! **CAUTION:** The compounds used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid contacting them with your skin or clothing. Be sure there are no open flames in the lab during this experiment. Notify your teacher immediately if an accident occurs.

2. Prepare the computer for data collection
   
   • Prepare the computer for data collection by opening the experiment file. Go to: Start → My computer → Extras on P files (O drive) → Science → Chemistry 332 → Lab-Evaporation

   • On the Graph window, the vertical axis has temperature scaled from 5 to 30°C. The horizontal axis has time scaled from 0 to 250 seconds.

3. Wrap the three probes with pieces of paper towels of similar size secured by small rubber bands as shown in Figure 1. Roll the filter paper around the probe tip in the shape of a cylinder. Hint: First slip the rubber band up on the probe; wrap the paper around the probe, and then finally slip the rubber band over the wrapped paper. The paper should be even with the probe end.

4. Stand probe 1 in the Ethylene Glycol tube, probe 2 in the Ethanol tube, and probe 3 in the Cyclohexane tube.

5. Prepare 3 pieces of masking tape to be used to tape the probes in position during Step 6.

6. After the probes have been in the liquids for at least 45 seconds, begin data collection by clicking **COLLECT.** Monitor the temperature for 15 seconds to establish the initial temperature of each liquid. Then simultaneously remove the probes from the liquids and tape them so the probe tips extend 5 cm over the edge of the table top as shown in Figure 1.

7. When both temperatures have reached minimums and have begun to increase, click **STOP** to end data collection.

8. Roll the rubber band up the probe shaft and dispose of the paper towels and rubber bands in the trash can.

9. Print out the results of your experiment and label each line by putting the correct name of the substance by its corresponding line on the graph.

10. Examine the structures of the three substances and decide what kind of intermolecular forces are present in each, dispersion forces or hydrogen bonding.

11. Using this information, make a prediction of the shape of the graph for chemical set #2. Decide which line will be which chemical base upon the structures.

12. Repeat the experiment but this time use chemical set #2: methanol, water, and acetone.

13. Print out the results of your experiment and label the three lines with the correct names of the substances.
PLW Evaporation and Intermolecular Attractions

<table>
<thead>
<tr>
<th>Substance</th>
<th>Formula</th>
<th>Structural Formulas</th>
<th>Molecular Weight</th>
<th>Hydrogen Bond (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclohexane</td>
<td>C₆H₁₂</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>C₃H₆O</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>Formula</th>
<th>Structural Formulas</th>
<th>Molecular Weight</th>
<th>Hydrogen Bond (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>H₂O</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>C₂H₄(OH)₂</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>Formula</th>
<th>Structural Formulas</th>
<th>Molecular Weight</th>
<th>Hydrogen Bond (Yes or No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>CH₃(OH)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td>C₂H₅(OH)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Is evaporation an endothermic or exothermic process?

2. Define evaporation by describing the molecules movement.
## Analysis of Evaporation Lab

### Set #1

<table>
<thead>
<tr>
<th>Substance</th>
<th>Electron Dot Structure</th>
<th>Polar Or Nonpolar</th>
<th>Type of Intermolecular Bond</th>
<th># of H Bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene Glycol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclohexane</td>
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</table>
## Analysis of Evaporation Lab

### Set #2

<table>
<thead>
<tr>
<th>Substance</th>
<th>Electron Dot Structure</th>
<th>Polar Or Nonpolar</th>
<th>Type of Intermolecular Bond</th>
<th># of H Bonds</th>
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<tbody>
<tr>
<td>Methanol</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TIE DYE PATTERNS

There are endless ways of getting patterns on your shirts. The first time you do this, you will want to give students some ideas. However, you will find that student become very creative and do things that we never thought about. I highly recommend that they do use patterns though rather than trying to write on shirts. The writing spreads and the shirts are usually not liked by the students the next day.

1) SPIRALS – Spread shirt out front side up. Grasp wherever you would like the center of spiral and carefully twist keeping the shirt flat. Your shirt will look like a pie shape. Now use bamboo skewers sticks and rubber bands to bind together. Be careful that the center of the spiral is not in a place you do not desire (like the center of your tummy, etc.) Squirt on dye like you are cutting a pie. You may do one color perhaps 8 ways and then take another color in the white areas in between. I recommend that you color all visible white for a striking shirt. You will always have some white where the folds are. Turn over and REPEAT.

2) MULTI-SPIRALS – You may make as many spirals as you desire. Again be careful where you choose. Two in breast area usually are not acceptable to young ladies. You may make each spiral different colors, etc. Get creative. Do both sides.

3) SPIDERS – Many of the students enjoy spiders with black (heavy metal types). Fold shirt in half lengthwise so that the back of shirt is to inside. Now grasp the shirt about 1/3 of the way from the neck and make a spiral. Place color on in pie shapes and then place BLACK dye on the other white areas (pie shape). Turn over and repeat on back side.

4) STRIPES – Fold shirt in half and fold accordion folds. If you want a V effect, place at 45° angle from neck. Squirt on dye perpendicular to folds. Bind together with rubber bands and sticks. Do not leave white unless you want a lot of white in your shirt.

5) FIRE – Grab pieces of shirt and twist bands around the areas.

6) CRINKLE – Lay shirt flat on table. Fluff up areas or grasp. Sprinkle dye on areas in pattern you like. This pattern is difficult to bind together with rubber ands and sticks but can be done.

7) STAR – This is more complicated, but very nice when finished. Lay the damp shirt on surface. Smooth out wrinkles. Fold in half so sleeves match. Fold back one side on the quarter line. Fold sleeve up. Turn shirt over and fold on quarter line on other side and fold sleeve up. Straighten out so you now have a long rectangle. You will now do a flag fold. (Have you ever folded a flag?) You will end up with a compact triangle. Your triangle has two sides equal and a longer side. Place your sticks on the two corners and bind with rubber bands. Now take your 1st dye color and squirt on all three corners. Make sure that you get enough so the dye permeates all folds. Then take a 2nd color and place on three sides. Let sit for 24 hours.
Spirals

Spider

Multi

(different parts of shirt)

Stripes

V-shape

Tear drop

Stae

(1)

(2)

(3) Flag fold

Fold, half

rubber band, then 
bamboo sticks and 
celt in edges.