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Module 4; Ionic vs. Covalent Compounds
Introduction

In this experiment you will test properties (melting temperature, solubility in water, and electrical conductivity of water solution) of substances which contain ionic bonds and substances which contain covalent bonds. You will use the results of your tests to identify differences between ionic and covalent substances. First, read the following information from your textbook and complete the table below:

Chemical bonds

Chemical Bonds are the attractive forces that hold atoms together. There are three basic types of bonds. **Ionic bond** is the electrostatic attraction between ions, in ionic compounds, after losing or gaining electrons among atoms. These usually occur between a metal and a nonmetal. **Covalent bond** is the sharing of electrons among atoms and usually occurs between two non-metals. (The third kind of bond is a metallic bond which is not covered in CHEM 1405).

Ionic Compounds

An **ionic compound** contains positively charged cations, usually made from metals which tend to lose electrons, and negatively charged anions, usually made from nonmetals which end to gain electrons. In some cases, ion charges can be determined by locating the element on a periodic table. Ionic compounds typically form when a metal atom **donates** an electron to become a cation and a non-metal atom **accepts** that electron to form an anion. The cation and the anion are held together *via* electrostatic attraction. The metal cation and non-metal anion must combine in a whole number ratio that results in a neutral compound.

Molecular Compounds

Compounds that exist as discrete molecules containing only non-metals are termed **molecular compounds.** Water (H2O), carbon dioxide (CO2), and ammonia (NH3) are molecular compounds that are common in everyday life. These are very different from **ionic compounds** like sodium chloride (NaCl) and silver nitrate (AgNO3). In a molecular compound, two atoms within the compound **share** electrons in the form of a **covalent bond**.

	IONIC COMPOUNDS	COVALENT COMPOUNDS (or MOLECULAR COMPOUNDS)
Two Examples	$NaCl$ $AgNO_3$	H_2O NH_3
Type of elements involved	Metals & Nonmetals	Nonmetals only
Type of bonding involved	Ionic Bonds	Covalent Bonds
Description of bonding involved	Valence electrons move from one atom to another to form ions	Valence electrons are shared between the atoms.

Procedure

You will observe three experiments in the assigned YouTube video. The link for the video is: https://youtu.be/VGXvCyPkTS8 (There is no sound/speaking initially in this video for observations. You will just watch it. But then there is speaking when the three tests are run.) Also notice that you will need to use your cell phone timer to record melting times.

1) While you are watching the video, complete the data table on the following page.

2) Also, while you are watching the video, answer the following questions about the procedure used in the experiment:

   a) In the solubility experiments, why does the scientist swirl the beaker?

   To ensure that the solvent is uniformly distributed within the solvent.

   b) In the solubility experiments, why does the scientist use the same amount of compound for each trial (0.05 moles) and the same amount of water (50 mL)? (Notice that in the melting point experiment he used 1.0 g for each trial).

   To ensure that the results are reliable through reducing the number of variables

   c) Before the conductivity tests are run, what does the scientist show you is required to light the light bulb?

   - A connection to a power source
   - The completion of the circuit across the light bulb by connection across a substance

   d) In the conductivity experiment, the scientist tests water by itself as a control. Why?

   To set a baseline for comparison and to show that the water is not conductive enough on its own to light the bulb.

   e) In the melting point experiments, what important tips did the scientist explain about using a Bunsen burner?

   - Use the hottest part of the flame (the inner core)
   - Be very safe
   - Use a crucible

   f) In the melting point experiment, the scientist defined the "end point" – the point at which you would stop the timer for each trial. How did he define the endpoint?

   The moment the substance begins to melt

Data Table

In the first column, indicate whether the chemical being tested is ionic or covalent. Some acids are also tested. You will be studying acids in module 8. In the last four columns, record your data from the experiment.

Chemical	Ionic or Covalent (or acid)	Solubility in Water – observation Record what you observe (compound disappears, floats, sinks, or makes the solution cloudy.)	Solubility in Water – inference Record the inference as **S** for soluble or **I** for insoluble.	Conductivity-Inference Record your inference; is the conductivity strong, weak or none.	State of compound – observation Record the state as solid (S), liquid (L) or gas (G).	Melting – Observation Record the time in seconds it takes for melting to start.
Potassium Iodide, KI	Ionic	Disappears	S	Strong	S	79
Potassium Chloride, KCl	Ionic	Disappears	S	Strong	S	Not Measureable
Glucose, $C_6H_{12}O_6$	Covalent	Disappears	S	None	S	12
Potassium Nitrate, KNO3	Ionic	Disappears	S	Strong	S	29
PDCB, $C_6H_4Cl_2$	Covalent	Sinks	I	None	S	4
Benzoic Acid, C_6H_5COOH	ACID	Sinks	I	None	S	10
Acetic Acid, CH_3COOH	ACID	Disappears	S	Weak	L	N/A
Paraffin, C_nH_{n+2}	Covalent	Sinks	I	None	S	8
Hydrochloric Acid, HCl	ACID	Disappears	S	Strong	G	N/A

Ionic vs. Covalent Bonds
Post Lab Questions

1. Looking at your data, what can you conclude in general about the water-solubility of covalent compounds versus ionic compounds?

Ionic compounds are generally soluble whereas covalent compounds are normally insoluble (but are sometimes soluble) in water.

2. Looking at your data, what can you conclude in general about the conductivity of covalent compounds versus ionic compounds?

Covalent compounds are strongly conductive whereas ionic compounds are not conductive

3. Looking at your data, what can you conclude in general about the melting point of covalent compounds versus ionic compounds?

The melting points of Ioniccompounds are generally high/higher than covalent compounds, which are generally low.

4. If a compound is soluble in water and conducts electricity when dissolved in water, is it likely a covalent or ionic compound? What is the key evidence for this?

It is likely to be an Ionic compound based on the data in the table, as compounds like Potassium Iodide and Potassium Chloride follow the same properties.

5. What is the difference between melting and dissolving? Give an example of a time you melt sugar. Give an example of a time you dissolve sugar.(You can give examples from daily life or from the previous labs you did.

Dissolution comes as a result of a physical mixing with another substance whereas melting is due to a change in temperature. I have melted sugar in the previous lab from last module.

6. In module 8, you will be studying acids. Do they seem to behave more like covalent or ionic compounds based on your data?

They behave more Ionically but have many typically covalent properties, like low melting points.

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Module 4; Making and Naming Ionic Compounds
Introduction

Elements/Compounds
Matter is anything that has mass and occupies space. Types of matter can be organized into several different categories. Pure substances are those that cannot be physically separated into different substances. Compounds are substances that can be separated into simpler substances only through chemical reactions. Salts, proteins, sugar, and dyes are all examples of compounds. Elements are the simplest form of matter that can be obtained through chemical reaction. The elements are all shown on the periodic table and include copper, gold, oxygen, and sulfur.

Reactions
Chemical reactions are processes in which one set of chemicals combine to form another set of chemicals. The initial set of chemicals are called reactants and the final set of chemicals are called products. Sometimes, it is not obvious that a chemical reaction has taken place. More often, however, there is a change in color, texture, shape, temperature, or other property to indicate that a reaction has occurred.

Reactions with copper to make ionic compounds
In the first three reactions you will observe the synthesis of ionic compounds from copper and one other element. Pennies will be the source of copper.

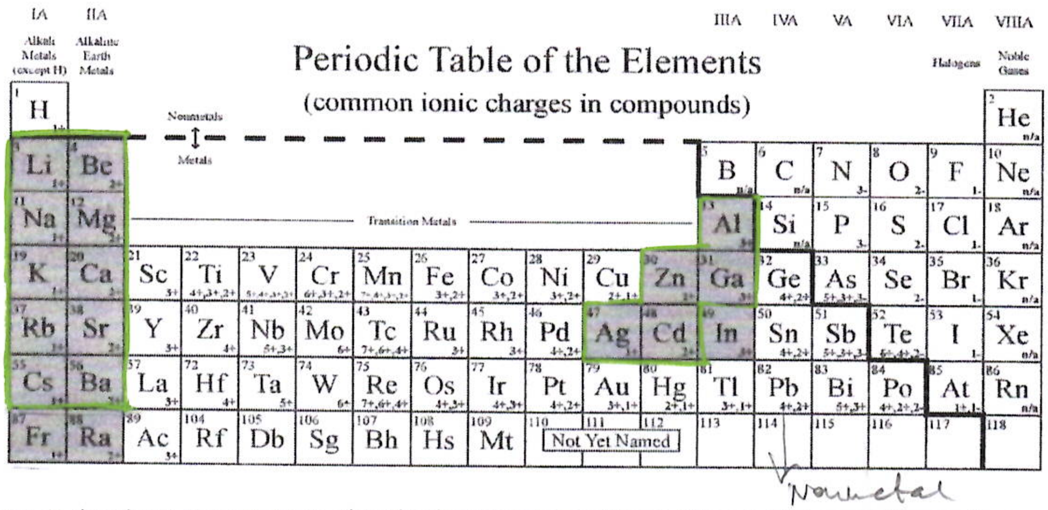
Reactions with oxygen to make ionic compounds
In the last three reactions, you will observe the synthesis of oxides (compounds with oxygen). Oxygen in the air will be the source of oxygen. Oxygen in the air is diatomic, O_2. Sometimes reactions need a "push" to get started. Usually, this push comes in the form of heat, which gives the reactants a burst of energy to start the reaction. The reactions forming oxides will need heat, which will be provided by a Bunsen burner flame to get the reaction started. The flame is NOT a reactant – it is energy used to get the reaction started.

Nomenclature
When the compounds are made in the demonstrations, you will also write the formulas and names for them. When naming compounds, first determine if the compound is ionic or covalent. Covalent compounds do not have a metal in them. Prefixes are used to name covalent compounds (carbon dioxide for CO_2 and Dinitrogen pentoxide for N_2O_5). If the compound is ionic, determine if the metal is a fixed metal or a variable metal. If it's a fixed metal, name the compound without any prefixes or Roman numerals (sodium chloride for NaCl, potassium nitride for K_3N). If the metal is a variable metal, find the charge on that metal and use a Roman numeral to show the charge (Nickel (III) chloride for $NiCl_3$, Nickel (II) oxide for NiO).

Note: In this lab, you will be observing four demonstrations from YouTube and doing one "kitchen" experiment. You will need the following materials for your experiment: Ziploc bag, penny, bleach, vinegar.

Pre-Lab Exercise.

Use the periodic table to answer the pre-lab questions below.



Note- In the above Periodic table, the shaded Metals are Fixed Charge Metals and rest other Metals are Variable charge.

Fixed F^{-1} -4 Trilead dinitride

Na_3N N_2O_4 CoF_3 CF_4 Pb_3N_2 KI S_4N_2 Tetrasulfur dinitride

Sodium nitride   Dinitrogen tetraoxide   Cobalt(III) flouride   Carbon tetrafluoride   Potassium Iodide

1) Provide the NAME (not the formula) as discussed in lecture/Notes on Naming compounds of all the compounds given above that are covalent:

- Dinitrogen tetraoxide
- Tetrasulfur dinitride
- Carbon tetrafluoride
- Trilead dinitride

2) Provide the NAME (not the formula) of all the ionic compounds with fixed metals. Identify the charge on each of those fixed metals (don't forget that a charge has both a sign and number such as +1 or -3).

- Sodium nitride   Na is +1
- Potassium Iodide   K is +1

3) Provide the NAME (not the formula) of all the ionic compounds with a variable metal. Identify the charge on each of those variable metals (don't forget that a charge has both a sign and number such as +1 or -3).

Cobalt (III) fluoride   Co is +3

Data and Data Analysis

In the following reactions, you will observe the combination of metals with nonmetals to make compounds: What kind of compounds will they be (ionic or covalent)? Ionic

The names of some of some of the ionic compounds will NOT have Roman Numerals in them. Why not?
Some of the metals will be fixed charge

The names of some of the ionic compounds you make will have Roman Numerals in them.
Why? Some of the metals will be variable charge

To determine the Roman Numeral, you need to know the charge on the metal in the compound.

NOTE: **Here's how you determine the charge of copper in an ionic compound based on appearance:**
Colorless copper compounds (including white) have copper (I) ions.
Colored copper compounds (red, black, green, blue) have copper (II) ions.
Exception: the red copper-oxygen product has a copper (I) ion.

COPPER AND CHLORINE

PROCEDURES	OBSERVATIONS	INFERENCES
Watch the following demonstration and answer the questions in columns 2 and 3. You will see the demonstration follow this procedure: 1) Bleach is in the bottle at the beginning of the reaction. 2) Sulfuric acid is dripped into the bottle. 3) Chlorine gas (Cl_2) is produced and trapped in the bottle. 4) A copper sheet is heated. 5) The hot copper sheet is then placed in the bottle with the chlorine gas. https://www.youtube.com/watch?v=edLpxdERQZc	What color are the reactants: Bleach: Light yellow Sulfuric Acid: Colorless/ Clear Copper sheet: Dark orange At first chlorine gas is produced. What color is the chlorine gas? yellow When chlorine gas is produced, is that a physical or chemical change? Chemical Then the copper and chlorine react. What color is that product? Turquoise/ Blue	The new color is due to the product created when copper (from copper sheet) and chlorine (from bleach) form an ionic compound that drips back into the bottle. What is the charge on the copper in your new ionic compound? (see highlighted note above) +2 Name the ionic compound formed: Copper (II) chloride Write the formula for the ionic compound you formed: $CuCl_2$

COPPER AND SULFUR		
PROCEDURES	**OBSERVATIONS**	**INFERENCES**
Watch the following demonstration and answer the questions in columns 2 and 3. You will see the demonstration follow this procedure: 1) Sulfur is put into a (dirty) test tube. What color is sulfur? Light yellow 2) A piece of copper wire is held in the test tube. What color is copper wire? Orange 3) The test tube is heated with a Bunsen burner. Observe the copper wire during the reaction. 4) The product is removed. https://www.youtube.com/watch?v=Jhu-0ACrMsQ	What color is the product? Dark Blue How is the product different than copper wire other than being a different color? It is incredibly brittle Is this a physical or a chemical change? Chemical	The new color is an ionic compound that is formed when copper (from the wire) reacted with sulfur. What is the charge on the copper ion in your new ionic compound? (see highlighted note above) +2 Name the ionic compound you formed: Copper (II) sulfide Write the formula for the ionic compound you formed: CuS

COPPER AND OXYGEN		
PROCEDURES	**OBSERVATIONS**	**INFERENCES**
Watch the following demonstration and answer the questions in columns 2 and 3. In this demonstration, a copper sheet is folded into an envelope. (The purpose of this is that the "inside" copper will get less oxygen than the "outside" copper.) It is held over a flame and heated. https://www.youtube.com/watch?v=1qZxJG8xMmQ	What color flame did you see? (Flame is energy, not matter, released by excited ions): Green, Yellow, Orange, and Blue The copper turns two different colors. What color is the inside of the copper sheet which got less oxygen? Pink What color is the inside of the copper sheet which got more oxygen? Black	Provide the formula and name for both products. (Remember the exception in the highlighted note above.) Pink Copper (I) Oxide $2Cu_2O$ Black Copper (II) oxide $2CuO$

IRON AND OXYGEN (steel wool and air)		
PROCEDURES	OBSERVATIONS	INFERENCES
Watch the following demonstration and answer the questions in columns 2 and 3. In the demonstration (with no sound), iron (steel wool) is heated and then dropped into a flask with oxygen in it. https://www.youtube.com/watch?v=TkE1uVjrY0w	The iron (steel wool) reacted with oxygen to make rust, Fe_2O_3. What color was the iron (Fe) you started with? Dark/silvery gray What color was the product? Brown Is the process of "rusting" a physical or chemical change? Chemical	Fe by itself (the steel wool), has no charge. What is the charge on the Fe in the rust, Fe_2O_3? ~~?~~ → 6− 3+ Provide the name of Fe_2O_3. Iron (III) oxide

HOME EXPERIMENT		
PROCEDURES	OBSERVATIONS	INFERENCES
You will need: bleach, Ziploc bag, vinegar, penny. Place a penny in the corner of a plastic bag. Add ½ tsp of household bleach to the corner of the bag with the penny. (CAUTION: bleach contains a highly reactive form of chlorine. Handle with care.) Next, add ¼ tsp of vinegar. Squeeze the excess air from the bag and seal it. Allow the liquid to stay in contact with the penny for several minutes. Observe the contents of the bag and record your observations. **Important: Take a picture of your home experiment (contents of the bag before cleanup) and attach it to your lab work along with your college ID or your picture.**	Record your observations from the experiment: The penny became less lustery and darker/grayer in color, and the bleach-vinegar solution became bright light blue. CLEAN UP To clean up, dilute the liquids with water and wash down the drain. Throw away the bag and the penny.	What do you think happened in this experiment? Be specific using what you learned from the previous four reactions in this lab. The copper in the penny must have reacted with the chlorine in the bleach to form Copper (II) ions, as proven by the blue color produced in the new chemical compound surrounding the penny.

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Module 4; Lewis Structures of Covalent Compounds

Pre-Laboratory Exercise

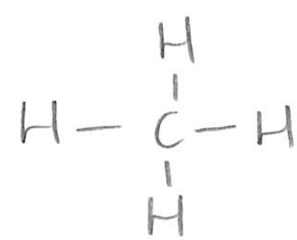
Before you watch the video for this exercise, draw the Lewis structures of the following molecules. You should have learned how to draw Lewis Structures in Lecture video on Ionic compounds and covalent compounds (Module 4). Draw them on scratch paper. You will check your work when you watch the video: Note: Be and B are exceptions to the octet rule.

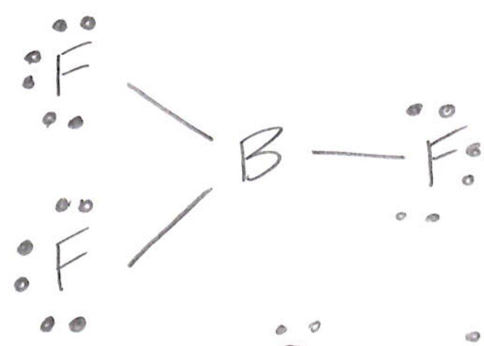
$BeCl_2$, CO_2, HCN, BF_3, CH_2O, SO_2, CH_4, NH_3, H_2O

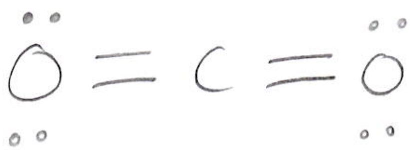
Laboratory Exercise

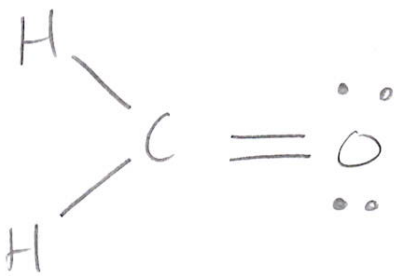
Print the following page. Complete the table as you watch the following YouTube video. Submit your completed table for grading. **Note: you will not be required to predict bond angles as the speaker does; you will be predicting shape only.**

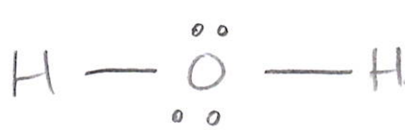
https://www.youtube.com/watch?v=nxebQZUVvTg

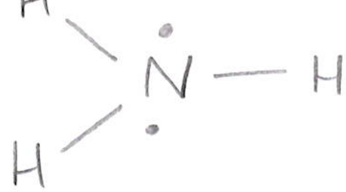


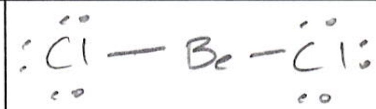
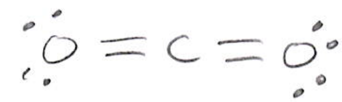
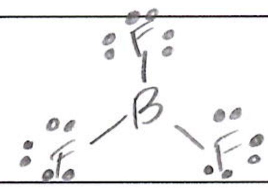
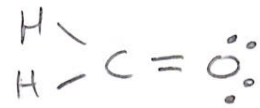
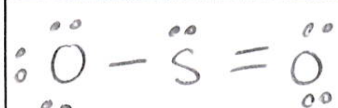
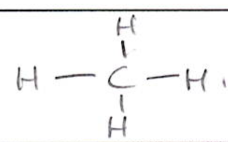
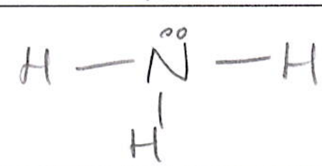
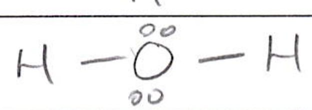










Molecule	Identify the **Central** Atom	Number of **atoms bonded to** <u>**central**</u> atom	Number of *non-bonding electron **pairs** around the <u>**central**</u> atom	Number of VSEPR Groups**	**Draw the Lewis structure showing the correct shape.** Use element symbols, dots for non-bonding electron pairs and dashes for bonded electrons.	Name the shape.
$BeCl_2$	Be	2	0	2		Linear
CO_2	C	2	0	2		Linear
HCN	C	2	0	2		Linear
BF_3	B	3	0	3		Trigonal Planar
CH_2O	C	3	0	3		Trigonal Planar
SO_2	S	2	1	2		Bent
CH_4	C	4	0	4		Tetrahedral
NH_3	N	3	1	3		Trigonal Pyramidal
H_2O	O	2	2	2		Bent

* The speaker uses the term "lone electron pair" instead of non-bonding electron pair. It is the same thing.
**Number VSEPR Groups is equal to the number of atoms bonded to the central atom plus the number of non-bonding pairs.