**Key Ideas**

* Compounds can be differentiated by their chemical and physical properties. (3.1dd)
* Two major categories of compounds are ionic and molecular (covalent) compounds. (5.2g)
* Chemical bonds are formed when valence electrons are transferred from one atom to another (ionic), shared between atoms (covalent), mobile within a metal (metallic). (5.2a)
* In a multiple covalent bond, more than one pair of electrons are shared between two atoms. (5.2e)
* Molecular polarity can be determined by the shape of the molecule and the distribution of charge. Symmetrical (nonpolar) molecules include CO2, CH4, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH3, and H2O. (5.2l)
* When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases. (5.2c)
* When a bond is broken, energy is absorbed. When a bond is formed, energy is released. (5.2i)
* Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence configurations and tend not to bond. (5.2b)
* Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point. (5.2n)
* Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions. (5.2d)
* Electronegativity indicates how strongly an atom of an element attracts electrons in a chemical bond. Electronegativity values are assigned according to arbitrary scales. (5.2j)
* The electronegativity difference between two bonded atoms is used to assess the degree of polarity in a bond. (5.2k)
* Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with other nonmetals to form molecular (covalent) compounds. Ionic compounds contain polyatomic ions have both ionic and covalent bonding. (5.2h)



**Introduction to Bonding**

**SUBSTANCE GROUP #1:**

For each of the following substances, place the symbol of the first element in its spot on the periodic table using red ink. Then, place the symbol of the second element in the substance in its spot on the periodic table using black ink.

NaCl LiBr KF ZnCl2 Fe2O3 CuI2 Al2S3

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**QUESTIONS FOR SUBSTANCE GROUP #1:**

1. Where are all the first elements located on the periodic table (red symbols)?
2. Based on your knowledge about the periodic table, what “classification” would you give these elements? Metal or Non-Metal?
3. Where are all the second elements located on the periodic table (black symbols)?
4. Based on your knowledge about the periodic table, what “classification” would you give these elements? Metal or Non-Metal?

**SUBSTANCE GROUP #2**

For each of the following substances, place the symbol of the first element in its spot on the periodic table using a red ink. Then, place the symbol of the second element in the substance in its spot on the periodic table using black ink.

CCl4 P2O5 N2O4 NI3 PBr3 F2Se

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**QUESTIONS FOR SUBSTANCE GROUP #2:**

1. Where are all the first elements located on the periodic table (red symbols)?
2. Based on your knowledge about the periodic table, what “classification” would you give these elements? Metal or Non-Metal?
3. Where are all the second elements located on the periodic table (black symbols)?
4. Based on your knowledge about the periodic table, what “classification” would you give these elements? Metal or Non-Metal?

**TYING IT TOGETHER:**

1. Group 1 substances are called ionic compounds and Group 2 substances are called covalent molecules. Write a simple rule that will allow you to classify compounds as ionic or covalent on the basis of what you have learned from the model.
2. Did the subscripts (the little numbers shown in the compound formulas) provide any insight into determining whether a substance is ionic or covalent? Why or why not?

**ELEMENT EVALUATION:**

Fill in the following tables identifying the type of element present in the substance. Use “M” for metal, and “NM” for non-metal.

|  |  |  |  |
| --- | --- | --- | --- |
| **FORMULA** | **1ST ELEMENT (M or NM)** | **2ND ELEMENT(M or NM)** | **CLASSIFICATION****(Ionic or Covalent?)** |
| **NaBr** |  |  |  |
| **SF6** |  |  |  |
| **CoBr2** |  |  |  |
| **BaS** |  |  |  |
| **NO2** |  |  |  |
| **C6H6** |  |  |  |
| **CrCl3** |  |  |  |
| **CO2** |  |  |  |
| **MnO2** |  |  |  |
| **PbCl2** |  |  |  |
| **OF2** |  |  |  |
| **CsF** |  |  |  |

**Types of Bonds**

*Complete the Venn diagram below with properties of ionic and Covalent Bonds:*

****

Covalent Bonds

Ionic Bonds

**Bonds formed between two nonmetals are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and involve the \_\_\_\_\_\_\_\_\_\_\_\_ of electrons.**

**Bonds formed between two metals are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and involve the \_\_\_\_\_\_\_\_\_\_\_\_ of electrons.**

**Bonds formed between metals and nonmetals are \_\_\_\_\_\_\_\_\_\_\_\_ and involve the \_\_\_\_\_\_\_\_\_\_\_ of electrons.**

*Describe the following as ionic, metallic, or covalent:*

NaCl \_\_\_\_\_ Al \_\_\_\_\_ Lithium \_\_\_\_\_

CO2 \_\_\_\_\_C6H12O6 \_\_\_\_\_ Strontium bromide \_\_\_\_\_

Au \_\_\_\_\_ Ti \_\_\_\_\_ Tin (II) chloride \_\_\_\_\_

MgBr2 \_\_\_\_\_K2O \_\_\_\_\_ Nitrogen (IV) oxide \_\_\_\_\_

Fe \_\_\_\_\_ CH4 \_\_\_\_\_ Hydrogen selenide \_\_\_\_\_

H2O \_\_\_\_\_ H2S \_\_\_\_\_ Copper (II) phosphate \_\_\_\_\_

Ca3(PO4)2 \_\_\_\_\_PI3 \_\_\_\_\_ Lead (IV) nitrate \_\_\_\_\_

**Geometry of the Ionic Crystals Introduction**



1. What is the electrical charge on the Na and Cl atoms in these crystals?
2. The diagrams only show a portion of the crystal. What is the entire crystals’ charge?
3. What force holds the crystals together?
4. Can you identify any specific, singular NaCl molecules in the crystal? Why?
5. NaCl is shaped like a cube. Would BaCl2 be shaped the same? Why?
6. Ionic crystals are hard, shatter easily and are bad conductors with high melting points. Contrast ionic crystals with metallic crystals.

**Ionic Compound Review**

All compounds form because elements want to form a stable \_\_\_\_\_\_\_\_\_\_\_\_\_ of valence electrons.

Ionic compounds form when \_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ electrons.

An example of an ionic crystal found at home is: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Circle the properties of ionic compounds:*

 Hard or soft High or Low melting point Crystalline or not crystalline

 Transfer or share High or Low boiling point Conductive or nonconductive



**Ionic Lewis Structures Introduction**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Element** | **Metal or Nonmetal?** | **Lewis Dot Structure****as an ATOM** | **Gain or lose electrons?** | **How many e-?** | **Lewis Dot Structure****of Stable ION** | **Becomes like which noble gas?** |
| Fluorine |  |  |  |  |  |  |
| Lithium |  |  |  |  |  |  |
| Aluminum |  |  |  |  |  |  |
| Sulfur |  |  |  |  |  |  |
| Radium |  |  |  |  |  |  |
| Phosphorous |  |  |  |  |  |  |

**Using your chart, draw Lewis structures for the following compounds:**

Lithium Phosphide

Lithium Sulfide

Lithium Fluoride

Radium Phosphide

Aluminum Phosphide

Radium Sulfide

Aluminum Sulfide

Radium Fluoride

Aluminum Fluoride

Summarize:

-Why do metals bond with nonmetals?

-What determines how many atoms of the metal and nonmetal will combine to form the compound?

**Lewis Dot Structures Practice**

How many valence electrons do cations show in the Lewis dot diagrams? \_\_\_\_ anions? \_\_\_\_

Draw the following ionic compounds and give their formula and/or name:

|  |  |  |  |
| --- | --- | --- | --- |
| **Lewis Diagram** | **Formula** | **Lewis Diagram** | **Name** |
| Sodium fluoride |  | CsCl |  |
| Potassium oxide |  | MgO |  |
| Rubidium nitride |  | SrI2 |  |
| Calcium bromide |  | BaS |  |
| Strontium sulfide |  | Fe2O3 |  |
| Magnesium phosphide |  | Ag2S |  |
| Aluminum iodide |  | CuO |  |
| Copper (I) sulfide |  | NiCl3 |  |
| Chromium (III) nitride |  | TiO2 |  |
| Manganese (IV) oxide |  | PtCl2 |  |

**Lattice Energy**

Ionic bonds contain cations and anions that have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ electrons and attracted each other due to their \_\_\_\_\_\_\_\_\_\_ charges. The strength of the ionic bond is largely due to the lattice energy. Lattice Energy is the energy released when gaseous ions create a solid ionic compound. Lattice energy depends on the charge and radii of the ions. The lattice energy will be a large value if the charges are \_\_\_\_\_\_\_\_\_\_\_\_\_ and the radii are \_\_\_\_\_\_\_\_\_\_\_, making the ionic compound stronger.

1. Why will ionic compounds formed with large positive and large negative ions be stronger than those formed with +1 and -1 ions?
2. Why will ionic compounds formed with smaller cations and anions be stronger than those formed with large ions?
3. Which is more important: the ionic charge or the radii? Why?
4. Draw a particle view (ions attracting) to describe your answers to questions 1-3.
5. Circle the compound in each set that has a stronger ionic bond. Explain your answer.
	1. LiF versus KF
	2. CaO vesus MgO
	3. Li2O versus LiCl
	4. AlCl3 versus LiF
6. Describe which lattice will have a higher lattice energy

in the picture on the right.

**Properties of Bonds Review**

**1. Use information in the table below to identify each compound as Ionic or Covalent Compounds.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Compound** | **Phase at Room Temperature** | **Conductivity as a pure solid** | **Conductivity as a liquid** **(aq or molten)** | **Melting Point** | **Ionic or Covalent** |
| **A** | solid | no | yes | 1049oC |  |
| **B** | solid | no | no | 223oC |  |
| **C** | liquid | no | no | 20oC |  |
| **D** | solid | no | yes | 378oC |  |
| **E** | liquid | no | no | -94oC |  |
| **F** | solid | no | yes | 650oC |  |

List the properties of Ionic compounds: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

List the properties of Covalent compounds: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**2. For each example, check if it describes breaking or forming bonds:**

|  |  |  |
| --- | --- | --- |
|  | Breaking bonds | Forming bonds |
| The stability of the system increases |  |  |
| N2 🡪 N + N |  |  |
| Endothermic |  |  |
| I + I 🡪 I2 |  |  |
| The stability of the system decreases |  |  |
| Exothermic |  |  |

**3. For each example provide the molecule, bond and determine when and if it conducts electricity:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Type of Bond**(Metallic, ionic, covalent, both ionic and covalent) | **Type of Molecule**(metallic, ionic, molecular) | **Conducts electricity?**(check all that apply)No (s) (l) (aq) |
| 1. Li2O
 |  |  |  |  |  |  |
| 1. AlCl3
 |  |  |  |  |  |  |
| 1. F2
 |  |  |  |  |  |  |
| 1. CH4
 |  |  |  |  |  |  |
| 1. HI
 |  |  |  |  |  |  |
| 1. Fe
 |  |  |  |  |  |  |
| 1. Na3PO4
 |  |  |  |  |  |  |
| 1. CaO
 |  |  |  |  |  |  |
| 1. C (diamond)
 |  |  |  |  |  |  |
| 1. C (graphite)
 |  |  |  |  |  |  |
| 1. H2
 |  |  |  |  |  |  |
| 1. Na
 |  |  |  |  |  |  |
| 1. NH4Br
 |  |  |  |  |  |  |
| 1. KNO3
 |  |  |  |  |  |  |
| 1. O3
 |  |  |  |  |  |  |
| 1. SiO2
 |  |  |  |  |  |  |
| 1. NH3
 |  |  |  |  |  |  |
| 1. FeBr2
 |  |  |  |  |  |  |
| 1. Hg
 |  |  |  |  |  |  |
| 1. CO2
 |  |  |  |  |  |  |

4. **Indicate which type of substance is described by each statement.**

|  |  |  |
| --- | --- | --- |
|  |  | ***Type of substance*** |
| a. | Can conduct electricity in the solid and liquid phases |  |
| b. | A soft substance whose atoms are held together by covalent bonds |  |
| c. | Low melting point and poor electrical conductor |  |
| d. | Can conduct electricity when aqueous or molten (liquid) |  |
| e. | Can be polar or nonpolar |  |
| f. | Can dissolve in water to produce mobile ions |  |

1. **Explain the following in terms of charged particles:**
	1. liquid mercury is a good electrical conductor
	2. molten NaCl conducts electricity while solid NaCl does not
	3. an aqueous solution of KBr conducts electricity while solid KBr does not
	4. CH4 is a poor electrical conductor

**Covalent Lewis Dot Diagrams Introduction**

1. All nonmetals (with the exception of H and He) will have between \_\_\_\_\_\_ and \_\_\_\_\_ valence electrons. Nonmetals tend to \_\_\_\_\_\_\_\_ valence electrons to obtain a stable octet. When two nonmetals react they form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds. Draw Lewis dot diagrams for the following species:

 **F Cl Br I O S**

**Se Te N P C**

2. Can these atoms create ionic bonds with one another? Will they transfer electrons to one another? Why or why not?

3. If these nonmetals need 8 valence electrons to become stable, how can they obtain electrons other than transferring electrons to one another? (Think about what you would do in your life if you needed a pencil for a lab but only one member of the lab group had a pencil.)

4. Show how a fluorine atom might bond with a chlorine atom in order for them both to obtain an octet.

5. Show how a fluorine atom might bond with an iodine atom in order for them both to obtain an octet. How is this similar to fluorine bonding with chlorine?

6. Show how a fluorine atom might bond with an oxygen atom in order for them both to obtain an octet. Compare this bond with the previous bonds.

**Covalent Lewis Dot Diagrams**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Compound** | **Total valence electrons** | **Lewis Diagram** | **Shape** | **Shared pairs** | **Unshared pairs** | **Bond Angle** |
| H2 |  |  |  |  |  |  |
| F2 |  |  |  |  |  |  |
| O2 |  |  |  |  |  |  |
| H2O |  |  |  |  |  |  |
| OF2 |  |  |  |  |  |  |
| NH3 |  |  |  |  |  |  |
| BCl3 |  |  |  |  |  |  |
| CH4 |  |  |  |  |  |  |
| SiF4 |  |  |  |  |  |  |
| SCl2 |  |  |  |  |  |  |
| CCl4 |  |  |  |  |  |  |
| AsF3 |  |  |  |  |  |  |
| **Compound** | **Total valence electrons**  | **Lewis Diagram** | **Shape** | **Shared Pairs** | **Unshared Pairs** | **Bond Angle** |
| N2 |  |  |  |  |  |  |
| H2S |  |  |  |  |  |  |
| SiBr4 |  |  |  |  |  |  |
| PH3 |  |  |  |  |  |  |
| Cl2 |  |  |  |  |  |  |
| BF3 |  |  |  |  |  |  |
| HF |  |  |  |  |  |  |
| H2Te |  |  |  |  |  |  |
| I2 |  |  |  |  |  |  |
| CI4 |  |  |  |  |  |  |
| CO2 |  |  |  |  |  |  |
| HCN |  |  |  |  |  |  |

**Covalent Lewis Diagrams Summary**

1. Compounds with 2 atoms are always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_shaped.
2. Compounds with 3 atoms are either \_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_ shaped.
3. What determines which shape the molecule will take? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Compounds with 4 atoms are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ shaped.
5. Compounds with 5 atoms are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ shaped.
6. Single bonds share \_\_\_\_\_ electrons and are the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds.
7. Double bonds share \_\_\_\_\_ electrons.
8. Triple bonds share \_\_\_\_\_ electrons and are the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds.
9. Halogens always bond \_\_\_\_\_\_\_ time(s) because they have \_\_\_\_\_ valence and need \_\_\_\_ electrons to fill the valence.
10. Chalcogens (oxygen’s group) always bond \_\_\_\_\_\_\_ time(s) because they have \_\_\_\_\_ valence and need \_\_\_\_ electrons to fill the valence.
11. Nitrogen’s group always bond \_\_\_\_\_\_\_ time(s) because they have \_\_\_\_\_ valence and need \_\_\_\_ electrons to fill the valence.
12. Carbon’s group always bond \_\_\_\_\_\_\_ time(s) because they have \_\_\_\_\_ valence and need \_\_\_\_ electrons to fill the valence.
13. Hydrogen always bonds \_\_\_\_\_\_\_ time(s) because they have \_\_\_\_\_ valence and need \_\_\_\_ electrons to fill the valence.



**Bond Polarity Introduction**

 1 2 13 14 15 16 17 18

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

In the empty spaces of the chart above, fill in the element symbols and electronegativity values. Notice the transition metals are absent.

1. Electronegativity values generally \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ down a group and \_\_\_\_\_\_\_\_\_\_\_\_ across a period.
2. Metals tend to have \_\_\_\_\_\_\_\_\_\_\_\_ electronegativity values and nonmetals are \_\_\_\_\_\_\_\_\_\_\_\_\_ values.
3. When lithium bonds with fluorine they form an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bond.
	1. What is the electronegativity difference of lithium and fluorine that might help characterize the properties they have? \_\_\_\_\_
	2. List some of the properties:
4. When fluorine bonds with another fluorine atom they form a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bond.
	1. What is the electronegativity difference of the two fluorine atoms that might help characterize the properties they have? \_\_\_\_\_
	2. List some of the properties:
5. When hydrogen bonds with fluorine atom they form a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bond.
	1. What is the electronegativity difference of the hydrogen and fluorine atoms that might help characterize the properties they have? \_\_\_\_\_
	2. List some of the properties:
6. HF and F2 are both \_\_\_\_\_\_\_\_ compounds, but they actually have some slightly different properties. F2 is not attracted to an electromagnetic field, where HF is. HF has a high boiling point, but F2 is very low. Based on the information you obtained so far, what characteristic might cause these differences?

**Bonding Rules:**

1. All diatomic elements such as \_\_\_\_, will have an electronegativity difference of \_\_\_\_ and have low boiling points and weak attractions with one another. These will be considered nonpolar covalent compounds. Since both atoms have the same electronegativity value, they share the electrons equally.
2. Compounds created using nonmetals that have the same electronegativity value such as \_\_\_\_ and \_\_\_\_ will also be nonpolar covalent compounds. Since both atoms have the same electronegativity values, they share the electrons equally.
3. Compounds created using nonmetals with similar electronegativity values in which the difference rounds to zero, (0-0.4) such as elements \_\_\_\_ and \_\_\_\_ will also be nonpolar covalent compounds. Since both atoms have similar electronegativity values, they share the electrons equally.
4. Compounds created using nonmetals with different electronegativity values in which the difference rounds to one, (0.5-1.4) such as elements \_\_\_\_ and \_\_\_\_ will have higher boiling points and attract to each other more. These will be known as polar covalent compounds. Since the atoms have different electronegativity values, they share the electrons unequally; the \_\_\_\_(more/less) electronegative element wil have the electrons more of the time and obtain a slightly \_\_\_\_ charge.
5. Compounds created using metals and nonmetals will have large electronegativity differences in which the difference rounds to two, such as elements \_\_\_\_ and \_\_\_\_. These will be known as ionic compounds.
6. Fill in the chart below:

|  |  |
| --- | --- |
| **Electronegativity Difference** | **Type of Bond** |
| 0.0-0.4 |  |
| 0.5-1.4 |  |
| 1.5-4.0 |  |

**Using your table above find the electronegativity difference for each substance. If more than one bond is formed, find all differences. Then, check which bonds are present.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Substance** | **Electronegativity difference(s)** | **Ionic** | **Covalent** | **Polar** | **Nonpolar** |
| I2 |  |  |  |  |  |
| PCl3 |  |  |  |  |  |
| SiO2 |  |  |  |  |  |
| Br2 |  |  |  |  |  |
| CO2 |  |  |  |  |  |
| NaCl |  |  |  |  |  |
| CH4 |  |  |  |  |  |
| N2O5 |  |  |  |  |  |
| NH3 |  |  |  |  |  |
| KCl |  |  |  |  |  |
| NaNO3 |  |  |  |  |  |
| KClO3 |  |  |  |  |  |
| Ca(ClO3)2 |  |  |  |  |  |

**Bonding Polarity Practice**

1. Indicate which atom will have the positive charge and which will have the negative charge in the following polar bonds:

 H-Cl H-F S-F N-O

1. Organize the following in order from least to most polar bonds: HCl, HF, H2O, NH3, HI
2. Identify and explain each bond drawn below:

|  |  |  |
| --- | --- | --- |
|  | **Type of Bond** | **Explanation** |
|  |  |  |
|  |  |  |
|  |  |  |

1. **For each statement check if it describes ionic, polar covalent, nonpolar covalent, or metallic bonds:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ionic | Polar Covalent | Nonpolar Covalent | Metallic |
| A transfer of electrons between two atoms |  |  |  |  |
| Positive nuclei dispersed in a sea of mobile electrons |  |  |  |  |
| Metals and nonmetals bonding |  |  |  |  |
| One atom loses, and another atom gains electrons |  |  |  |  |
| Two atoms share electrons equally |  |  |  |  |
| Metals bonding only |  |  |  |  |
| Electronegativity differences under 0.4 |  |  |  |  |
| A bond resulting from electrostatic charges between opposite charged particles |  |  |  |  |
| Two atoms share elecrons unequally |  |  |  |  |
| Nonmetals bonding only |  |  |  |  |
| Electronegativity differences over 1.7 |  |  |  |  |

**Molecular Polarity**

Fill in the chart below.

**Molecule**

**Distribution of charge?** (symmetrical or asymmetrical)

1. In terms of lone pair electrons, how can you determine if a molecule is polar?
2. What molecular shapes are always polar?
3. What molecular shapes are always nonpolar?
4. How can a molecule be nonpolar if it contains polar bonds?

**Go back to the Covalent Lewis diagrams you drew on pages 9 and 10. Determine if the molecules were polar or nonpolar and place P or NP in the margin to the left of the name.**

**Molecular Polarity** (polar or nonpolar molecule)

**Molecular Shape** (linear, pyramidal, tetrahedral, or bent)

**Bond Polarity** (polar or nonpolar covalent)

**Bond Energy Introduction**

1. When bonds are formed, the new substance is \_\_\_\_(more/less) stable and therefore the reaction will \_\_\_\_\_\_\_(absorb/release) energy.
2. When bonds are broken, the new substances are \_\_\_\_(more/less) stable and therefore the reaction will \_\_\_\_\_\_\_(absorb/release) energy.
3. When energy is released the value is \_\_\_(+/-) and labeled \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(endo/exo)thermic.
4. When energy is absorbed the value is \_\_\_(+/-) and labeled \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(endo/exo)thermic.

**Bond Energy Practice**

**For each of the reactions, draw the structure of the compounds and then find the change in enthalpy of reaction (ΔHrxn). Assume all elements and compounds are in the gas phase unless noted otherwise.**

1. H2 + Cl2 🡪 2HCl
2. N2 + 3H2 🡪 2NH3
3. N2H4 + 2F2 🡪 N2 + 4HF

**Bond Order**

1. Which species used above has the highest bond order? Why?
2. Which species used above has the shortest bond length? Explain your answer.
3. Compare the bond strengths of N2 and H2. Justify your answer.

**Intermolecular Forces Notes**

Define the words to complete the following chart:

London Dispersal:

Strength:

Example:

Dipole-Dipole:

Strength:

Example:

Hydrogen “Bonds”:

Strength:

Example:

Ion- Dipole:

Strength:

Example:

Covalent Bonds:

Properties:

Example:

Metallic Bonds:

Properties:

Example:

Ionic Bonds:

Properties:

Example:

Intermolecular Forces:

Intramolecular Forces:

Compound:

**Intermolecular Forces**

|  |  |  |  |
| --- | --- | --- | --- |
|  | London Forces/VDW | Dipole Forces | Hydrogen Bonds |
| Type of molecule |  |  |  |
| Strength |  |  |  |
| Example |  |  |  |

1. Generally, all physical changes involve changes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and chemical changes involve changes in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Use forces to explain the following phenomenon:**

1. List the noble gases with their boiling points in order. They all do not bond, so why are they not all the same value?
2. Why does gasoline (C8H18) remain in the liquid phase but our Bunsen burner gas made out of the same elements (CH4) remain in the gas phase?
3. Why does dry ice sublime at room temperature but sugar and salt don’t even melt?
4. Why is sodium chloride’s melting point much higher than sugar’s (C6H12O6)?
5. Explain why this data makes sense for the last three compounds, but not the first?

|  |  |  |
| --- | --- | --- |
|  | **Molar mass** | **Boiling Point (˚C)** |
| H2O | 18.0 | 100 |
| H2S | 34.1 | -62 |
| H2Se | 81.0 | -42 |
| H2Te | 129.6 | -2 |

1. What is the exception for the first compound?
2. Explain why this data makes sense for the last three compounds, but not the first?

|  |  |  |
| --- | --- | --- |
|  | **Molar mass** | **Boiling Point (˚C)** |
| HF | 20.0 | 19 |
| HCl | 36.5 | -84 |
| HBr | 80.9 | -67 |
| HI | 12.9 | -35 |

1. What is the exception for the first compound?
2. Identify the intermolecular forces that exist in the following molecules.

|  |  |
| --- | --- |
| Compound | Type of IMF |
| H2O |  |
| N2 |  |
| HCl |  |
| LiCl |  |

1. Surface tension is a result of strong intermolecular forces. Which of the compounds in question 10 has the strongest surface tension?
2. Some perfumes only last a short time while others have lasting odors.



**Unit 5 Bonding Chemistry Review**

**INTRODUCTION TO BONDING**

Elements are the simplest form of matter and cannot be decomposed. Compounds can be formed between two or more elements. They can be decomposed chemically.

 a. Which of the following is a compound? Ne H2O Be F

 b. Which of the following cannot be decomposed by chemical means?

 C12H24 NH3 Li CS2

Atoms bond in order to obtain a stable electron configuration, like noble gases, called the **octet**. Most atoms will gain or lose electrons in order to have eight valence electrons. However, small elements such as H, Li, and Be will settle for two valence electrons. Obtaining an octet makes the atoms more stable and they can release energy. The electrons obtain the octet by sharing or transferring electrons.

 a. Draw the Lewis dot diagram of the following elements:

 Na Mg Al Si

 P S Cl Ar

 b. Draw the Lewis dot diagram of the following ions:

 Na+ Mg+2 Al+3

 P-3 S-2 Cl-

 c. Explain why the metals lost electrons but the nonmetals gained electrons. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 d. Explain why Ar doesn’t form an ion. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 e. Fill the blanks with **release or absorb**: “When atoms bond they \_\_\_\_\_\_\_\_\_\_\_\_ energy. In order to break a bond, energy must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**IONIC BONDING**

Compounds that form between a metal and a nonmetal contain **ionic bonds**, transferring electrons. Ionic bonds are strong. Ionic compounds have high melting points, are generally solids at room temperature, and conduct in the liquid phase.

 a. Which of the following has ionic bonds? NaCl NH3 Mg

 b. Which of the following transfers electrons? MgBr2 Li CO2

 c. Which of the following has a higher melting point? Cu C6H12 LiF

 d. Which of the following can conduct in the aqueous phase? NO KI Ne

**COVALENT BONDING**

Compounds that form between two nonmetals have **covalent bonds,** sharing electrons. Covalent bonds are weaker than ionic bonds. Covalent compounds have low melting points, are generally gases, liquids, or powdery solids at room temperature, and never conduct. These are also known as **molecular compounds**.

 a. Which of the following has covalent bonds? HF LiCl Rb

 b. Which of the following shares electrons? H2O Ag CaCl2

 c. Which of the following can never conduct electricity? Kr Rb2O H2O

 d. Which of the following has both ionic and covalent bonds? Li NH3 CaCO3

e. Which of the following is a molecular compound? H2O Mg LiBr

**METALLIC BONDING**

**Metallic Bonds** form when a metal loses their valence electrons and a “sea of mobile electrons” form that allows the metal to conduct electricity in the solid or liquid phase.

 a. Which of the following is metallic? NaCl NH3 Mg

 b. Which of the following has a sea of mobile electrons? Cu C6H12 LiF

 c. Which of the following can conduct in the solid phase? Ne Ag CaCl2

**LEWIS STRUCTURES/GEOMETRY**

Ionic Lewis diagrams show the ions involve in the bond, but no arrangement. Covalent Lewis diagrams show the sharing of electrons with lines representing two electrons. They form shapes such as **linear, bent, pyramidal, and tetrahedral.**

1. Draw the following and give the number of shared pairs, unshared pairs, and the shape if applicable.

LiF NH3

MgF2 CH4

Cl2 H2O

**POLARITY**

Bonds are **polar** when two atoms have different electronegativities and share unevenly. The more electronegative atom has the electrons more of the time. **Nonpolar bonds** form when two atoms have the same electronegativity values and share equally.

1. Label the bonds as polar or nonpolar:

NH3 CH4 Cl2 H2O

Molecules are polar when the molecule is asymmetrical. They are nonpolar if the molecule is symmetrical.

1. Label the bonds as polar or nonpolar (Use your drawing to help you):

NH3 CH4 Cl2 H2O

**INTERMOLECULAR FORCES**

**Intermolecular forces** are what keeps molecules together (not atoms-that’s bonds) and are responsible for phases, phase changes, surface tension and various other properties. Nonpolar molecules have the weakest attractive forces dependent on their size (the bigger the stronger). Polar molecules have stronger forces dependent on their polarity. **Hydrogen bonds** are a special case of polar forces between H and either F,O, or N. Molecules that are hydrogen bonded have high melting and boiling points, strong surface tension, and have closely packed particles.

1. Which of the following has the highest melting point? \_\_\_\_\_\_

HF HCl HBr HI

1. Which of the above has the lowest boiling point? \_\_\_\_\_

**Chemistry Unit 5: Bonding**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Key Idea Question** | **Justify your answer** **with an explanation or calculation.**  | **Confidence Level****None Moderate Fully**http://www.mentisology.org/wp-content/uploads/2015/07/scale-1-10.jpg |
| 1 | Which describes: Br + Br 🡪 Br21. Bonds broken energy released
2. Bonds broken energy absorbed
3. Bonds formed energy released
4. Bonds formed energy absorbed
 |  | Pre-discussion: Post discussion:  |
| 2 | Which compound contains both ionic and covalent bonds?1. CH3OH c. LiOH
2. MgF2 d. CO2
 |  | Pre-discussion: Post discussion: |
| 3 | Which compound transfers electrons to form a crystal lattice structure that can be an electrolyte in solution?1. NaCl c. Mg
2. C6H12O6 d. HCl
 |  | Pre-discussion: Post discussion: |
| 4 | Multiple covalent bonds are described as1. Sharing 2 electrons
2. Transferring 2 electrons
3. Sharing 4-6 electrons
4. Transferring 4-6electrons
 |  | Pre-discussion: Post discussion: |
| 5 | Which is a nonpolar molecule with polar bonds?1. CO2 c. LiF
2. CH4 d. NH3
 |  | Pre-discussion: Post discussion: |
| 6 |  Boiling Point SolubilityXO 20C NoYO 2500C YesState evidence confirming YO has stronger forces than XO. |  | Pre-discussion: Post discussion: |
| 7 | Show how water orients itself around the ion: Na+ |  | Pre-discussion: Post discussion: |
| 8 | Draw the Lewis dot diagram for Cs2S.  |  | Pre-discussion: Post discussion: |
| 9 | Draw Lewis dot diagrams for the following and provide their shape: Cl2 H2S PCl3  CBr4 |  | Pre-discussion: Post discussion: |
| 10 | Explain why CH4 is nonpolar and H2O is polar in terms of distribution of electrons. |  | Pre-discussion: Post discussion: |

**Common Sense Chemistry Review Volume 5**

*I am transferring my knowledge to you. Isn’t it ionic?*

1. Charlie knows that melting sugar can create delicious caramel. Charlie also loves salty foods. He has an idea: melt salt and use it as a drizzle as well!
	1. Explain to Charlie- in terms of bond strength, melting points, and electrons- why melting the salt isn’t feasible.
	2. Charlie doesn’t believe you. He tries to melt salt in another pot anyway and thinks adding water will help. And then drops an electric mixer into the pot. Is it safe to pull out? Why or why not?
	3. If he dropped the mixer in the sugar melting, would he be more or less safe than the salt solution?
2. Explain why all salts are not compressible, hard structures whereas sugar can be powdery.
3. Nitrogen gas is a major component in the air. The amount of water vapor varies. Explain in terms of bond strength, why nitrogen gas is always present in the air and mainly non-reactive, while water vapor varies. Draw diagrams to elaborate.
4. Sometimes it takes forever to dry off from a shower or pool, but nail polish remover dries instantly. Explain this phenomenon.
5. Why won’t my oil and vinegar just mix already?
6. Explain in terms of bonds and forces, why methane (CH4, cow farts) is gaseous, but a compound made of the same elements, octane (C8H18, gasoline) is a liquid.
7. Explain why water is attracted to itself creating strong surface tension allowing lizards to run across the surface of lakes. Would water be as strong if oxygen has no lone pairs?