



# **ATOMIC BONDING**

Charlene Jackson

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## ATOMIC BONDING

Most atoms do not exist as single entities but are combined in compounds. They are unstable as their outer electron shells are not full except for group 8 atoms. They are stable and unreactive. Unstable atoms of the other elements will react with each other or other atoms to become stable. They will gain a full outer electron shell by:

- losing electrons from their outer shell,
- gaining electrons into their outer shell
- sharing their valence electrons

## IONIC BONDING

This occurs when a metal bonds with a non-metal. It involves the complete transfer of valence electrons from metals to non-metals. Metal atoms form positive ions and non-metals form negative ions. Both ions will have full outer shells and the opposite charges will strongly attract each other. Ionic bonding results in the formation of ionic compounds. eg. NaCl, MgO, Na<sub>2</sub>O, LiF, MgCl<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>.

**Example:** In the formation of Sodium Chloride, each sodium atom donates its one outer shell electron to a chlorine atom forming Na<sup>+</sup> and Cl<sup>-</sup> ions.

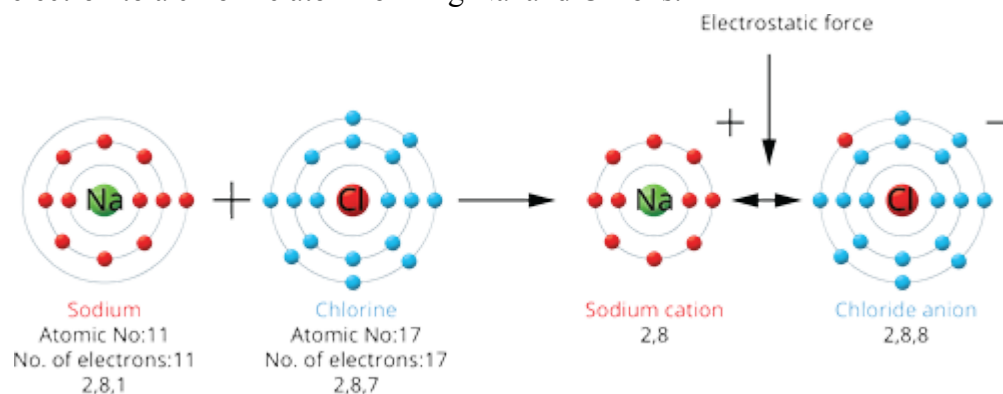


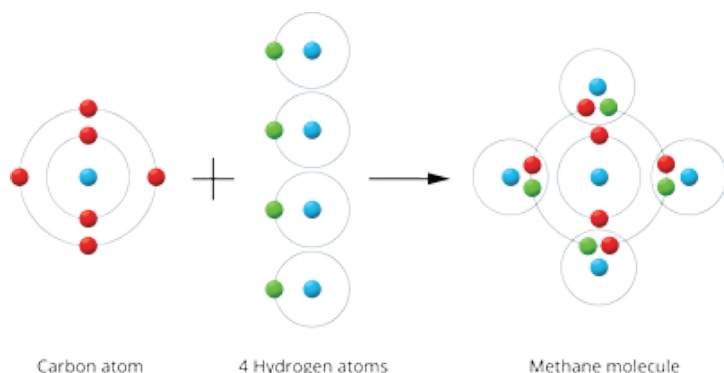
Figure 1: Formation of Sodium Chloride

## COVALENT BONDING

This occurs between non-metal atoms. It involves the sharing of valence electrons as all atoms seek to gain electrons to become stable. The shared electrons form strong covalent bonds. Covalent bonds result in the formation of molecules. Each atom donates equally to the covalent bond. Each bond (bonding pair of electrons) represents two electrons. When atoms donate one electron each a single bond is formed e.g., HCl, H<sub>2</sub>O, NH<sub>3</sub>, CH<sub>4</sub>. If two pairs of electrons are involved in the bond, a double is formed e.g., CO<sub>2</sub>, O<sub>2</sub>. When three electrons are donated by each atom, a triple bond is formed e.g., N<sub>2</sub>.

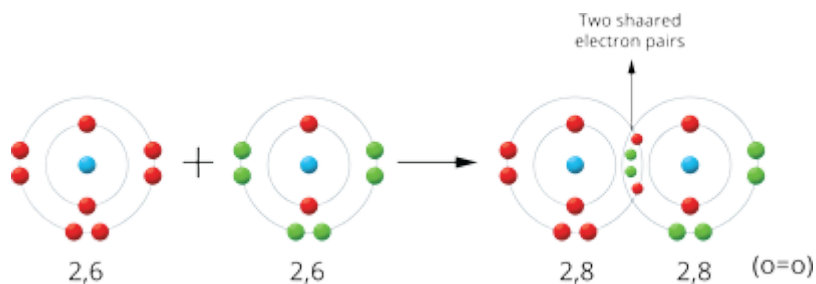
**Example of A single covalent bond:** In the formation of a Methane (CH<sub>4</sub>) molecule, A methane molecule is produced by the combination of one carbon and four hydrogen atoms. There are four valence electrons in a carbon atom (2,4). These four electrons are shared

with four hydrogen atoms to form a stable electronic configuration (octet), sharing a pair of electrons.



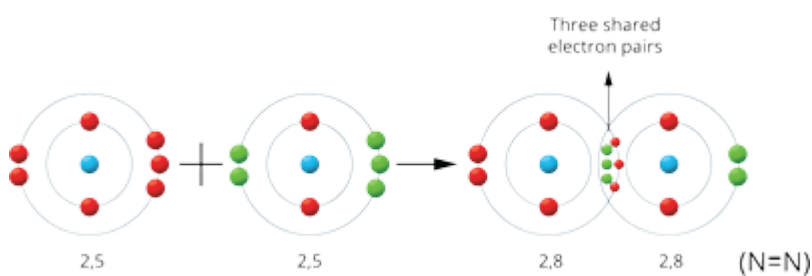
**Figure 2: Methane Molecule**

**Example of a double covalent bond:** In the formation of an Oxygen molecule ( $O_2$ ), Two oxygen atoms produce the oxygen molecule. The valence electrons of an oxygen atom are six (2,6). Therefore, these atoms share two pairs of electrons, resulting in a stable electronic configuration (octet). Thus, between the two atoms, a double bond is formed.



**Figure 3: Oxygen Molecule**

**Example of a triple covalent Bond:** In the formation of a Nitrogen ( $N_2$ ), Two nitrogen atoms produce the Nitrogen molecule. The valence electrons of a nitrogen atom are five (2, 5). Therefore, these atoms share three pairs of electrons, resulting in a stable electronic configuration (octet). Thus, between the two atoms, a triple bond is formed.

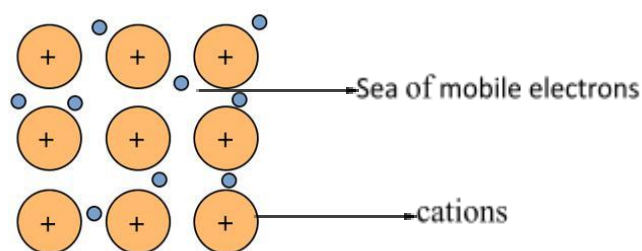


**Figure 4: Nitrogen Molecule**

## METALLIC BONDING

Metallic bonding takes place between atoms in metals. The atoms that are tightly packed will lose their valence electrons to form cations. The lost electrons will form a negatively charged cloud of electrons described as a sea of electrons. The mobile electrons will be attracted to the positively charged cations forming the metallic bond. The structure formed is described as cations embedded in a sea of electrons. The free electrons are responsible for the shiny nature of metals and their ability to conduct electricity. The more electrons an atom loses the harder the structure.

**Example:** Sodium only has one valence electron. So, in metallic bonding, it can only donate one electron to be delocalized throughout the structure. Hence if nine sodium atoms come together, there will be nine electrons that are donated to the sea of electrons.



**Figure 5: Metallic bonding in Sodium**

## ACTIVITY 1

Using the information provided above complete the Bonding Comparison table below.

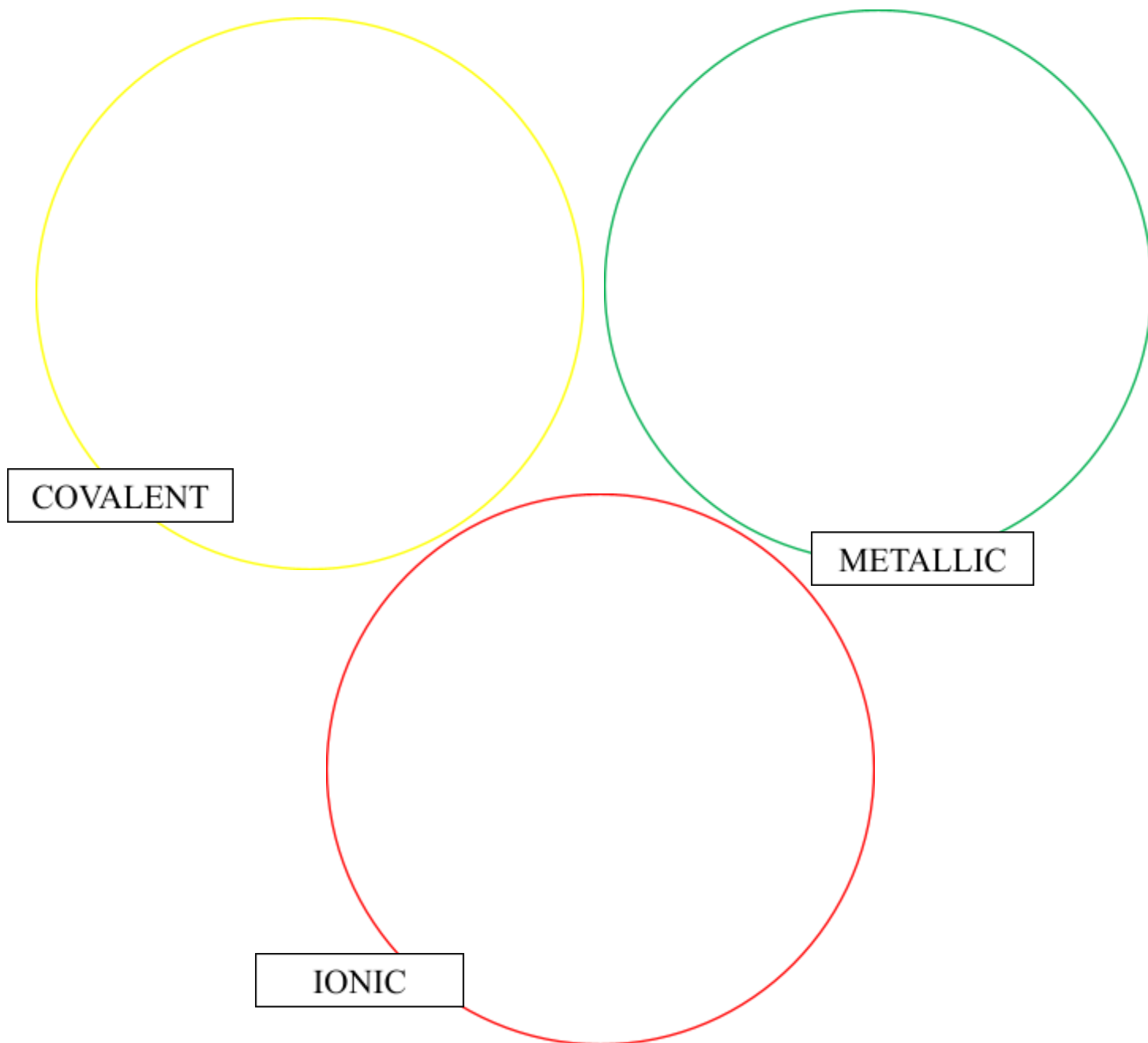
	IONIC	COVALENT	METALLIC
<b>Types of Atoms Involved</b> (Metal, Nonmetal)		Nonmetals	
<b>Method of Bond Formation</b> (Valence Electrons)	Positive ions bonding with negative ions... Transfer of Electrons		Valence electrons are shared among atoms... A Sea of Electrons
<b>Type of Structure</b>	Crystalline		
<b>Physical State</b> (Solid, Liquid or Gas)			Solid
<b>Melting/Boiling Point</b> (High or Low)		Low melting point	
<b>Solubility in Water?</b>	Soluble	Insoluble/soluble	
<b>Electrical Conductivity?</b>			Relatively high conductivity
<b>Other Properties</b>	Most are hard	Flammable	

## ACTIVITY 2

There are three types of atomic bonds: covalent, ionic, and metallic. Sort the compounds below into groups within the circles below according to their chemical bonding:

Caesium (Cs)	Sodium Chloride (NaCl)	Ammonia (NH <sub>3</sub> )	Lithium Oxide (Li <sub>2</sub> O)
Oxygen (O <sub>2</sub> )	Magnesium (Mg)	Barium Iodide (BaI <sub>2</sub> )	Magnesium Fluoride (MgF <sub>2</sub> )

Aluminium (Al)	Methane (CH <sub>4</sub> )	Magnesium Oxide (MgO)	Ethyne (C <sub>2</sub> H <sub>2</sub> )
Sodium Cyanide(NaCN)	Lithium Hydroxide (LiOH)	Phosphoryl Chloride (POCl <sub>3</sub> )	Sulfuric Acid (H <sub>2</sub> SO <sub>4</sub> )



### ACTIVITY 3

**Directions:** In the blanks, write the terms from the list that complete the definition. Words can be used more than once.

**positive      compound(s)      Electron (s)      charged      Force(s)      Atom(s)**

element (s)	Energy level(s)	negative	Number (s)	Ion(s)
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1. A chemical formula tells what \_\_\_\_\_ makes up a \_\_\_\_\_ and the exact \_\_\_\_\_ of atoms of each element in a unit of compound.
2. An atom is chemically stable when its outer \_\_\_\_\_ is completely filled with \_\_\_\_\_.
3. A chemical bond is a \_\_\_\_\_ that holds \_\_\_\_\_ together in a compound.
4. An \_\_\_\_\_ that has lost or gained \_\_\_\_\_ is called an ion.
5. An ionic bond is the \_\_\_\_\_ of attraction between the opposite charges of the \_\_\_\_\_ in an ionic \_\_\_\_\_.
6. The attraction that forms between \_\_\_\_\_ when they share \_\_\_\_\_ is known as a covalent bond.
7. A polar molecule has a slightly \_\_\_\_\_ end and a slightly \_\_\_\_\_ end.
8. A nonpolar molecule does not have oppositely \_\_\_\_\_ ends.
9. Only atoms that are exactly alike can share their \_\_\_\_\_ equally.

### ACTIVITY 4

**Directions:** Complete the sentence by writing the correct terms in the blanks.

1. An atom that has gained or lost electrons is called a(n) \_\_\_\_\_.
2. An atom is \_\_\_\_\_ when its outer energy level is filled with electrons.
3. A(n) \_\_\_\_\_ tells what elements make up a compound and the ratios of the atoms of those elements.
4. A molecule that has a positive end and a negative end is a(n) \_\_\_\_\_ molecule.
5. A bond that forms between atoms when they share electrons is a(n) \_\_\_\_\_ bond.
6. A positive or negative number that is assigned to an element to show its combining ability in a compound is a(n) \_\_\_\_\_.
7. An ion that has a positive charge is called a(n) \_\_\_\_\_.
8. When an atom gains an electron, it is called a(n) \_\_\_\_\_.
9. The force of attraction between the opposite charges of the ions in an ionic compound is a(n) \_\_\_\_\_.
10. Molecules that do not have oppositely charged ends are \_\_\_\_\_ molecules.

11. A(n) \_\_\_\_ is formed when atoms gain, lose, or share electrons.

### Activity 5

Instruction: Use lines to match each term with its description. Each term can only be matched once to its description.

#### Column I

- I. chemically stable
  
- II. Ionic bond
  
- III. Chemical bond
  
- IV. Covalent bond
  
- V. polar formula
  
- VI. Chemical bond
  
- VII. ion
  
- VIII. Nonpolar molecule

#### Column II

- A. Shorthand that tells what elements a compound contains and the exact number of atoms of each element in a unit of the compound
  
- B. Molecule made of two identical atoms that share the electrons equally
  
- C. Molecule that has a slightly positive end and a slightly negative end
  
- D. The force of attraction between the opposite charges of the ions in an ionic compound
  
- E. Describes an atom that has a full outermost energy level
  
- F. A charged particle that has either more or fewer electrons than protons
  
- G. The attraction that forms between atoms when they share electrons
  
- H. The force that holds atoms together in a compound

## ACTIVITY 6

**Instruction:** Complete the sentence by writing the correct terms in the blanks.

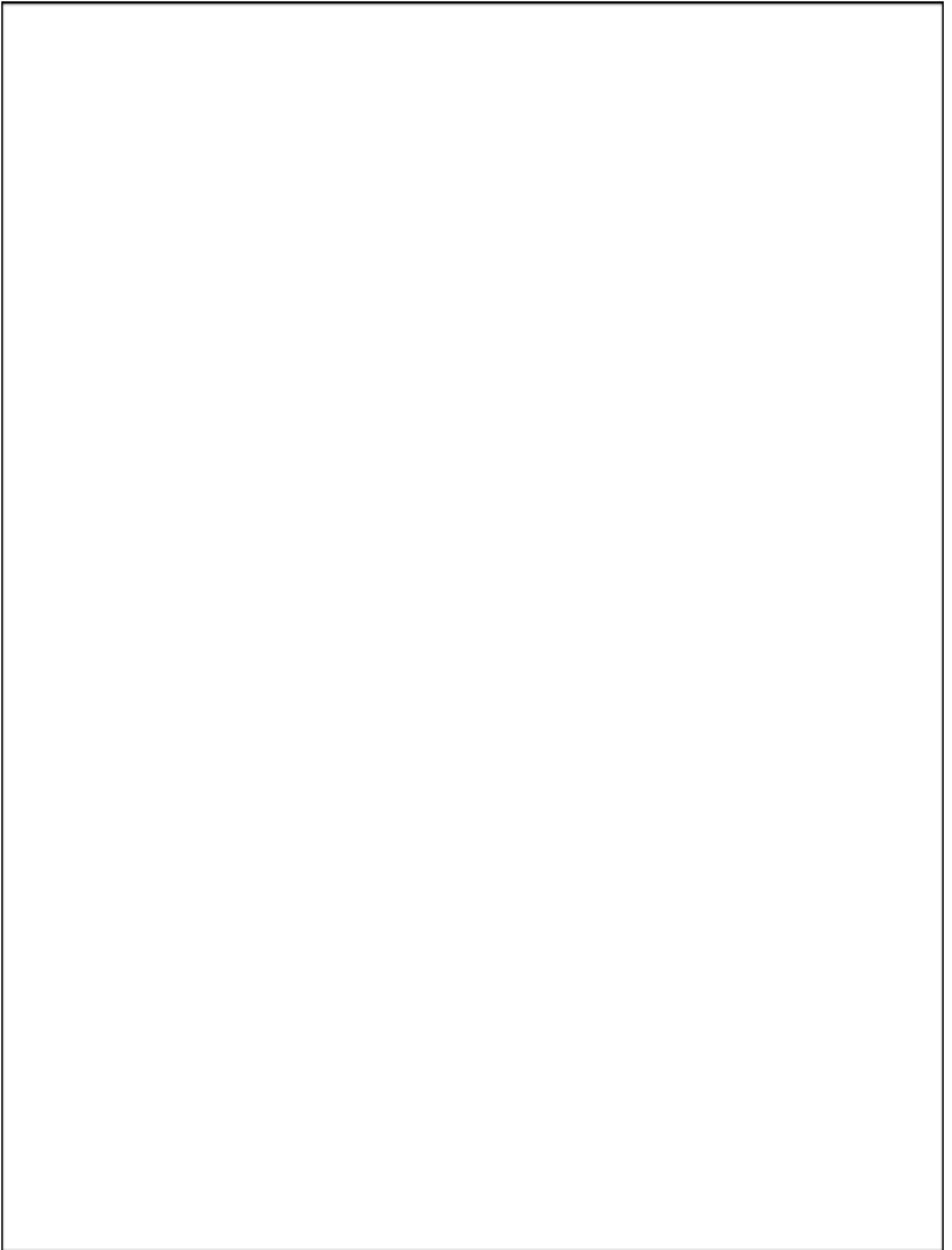
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9. The force of attraction between the opposite charges of the ions in an ionic compound is a(n) \_\_\_\_\_.
10. Molecules that do not have oppositely charged ends are \_\_\_\_\_ molecules.
11. A(n) \_\_\_\_\_ is formed when atoms gain, lose, or share electrons.

## ACTIVITY 7

**Instruction:** Draw dot and cross diagrams in the box provided to show the bonding in the following compounds.

1. Water  $\text{H}_2\text{O}$
2. Carbon Dioxide  $\text{CO}_2$
3. Ethyne  $\text{C}_2\text{H}_2$
4. Phosphorus Trichloride  $\text{PCl}_3$
5. Ammonia  $\text{NH}_3$
6. Hydrogen Chloride  $\text{HCl}$
7. Ethane  $\text{C}_2\text{H}_6$
8. Ethene  $\text{C}_2\text{H}_4$





## ACTIVITY 8

**Instruction:** All the statements below are false as written. In the space provided, write a term or phrase that makes the statement true when it is substituted for the highlighted words.

1. The properties of a compound are the same as the properties of the elements that it contains. \_\_\_\_\_.
2. Superscript numbers in chemical formulas tell how many atoms of each element are found in a unit of a compound. \_\_\_\_\_.
3. All noble gases except helium have 18 electrons in their outer energy level. \_\_\_\_\_.
4. A(n) chemical formula is the force that holds atoms together in a compound. \_\_\_\_\_.
5. An ion is a(n) neutral particle that has either more or fewer electrons than protons. \_\_\_\_\_.
6. Charges are written as subscripts. \_\_\_\_\_.
7. A(n) covalent bond is the force of attraction between the opposite charges of the ions in an ionic compound. \_\_\_\_\_.
8. The charge on the final compound is always positive. \_\_\_\_\_.
9. Equal sharing of electrons in covalent bonds results in polar molecules. \_\_\_\_\_.
10. Only two identical atoms can share electrons unequally. \_\_\_\_\_.
11. An anion is a positively charged ion. \_\_\_\_\_.
12. When an atom loses an electron, it is called an anion. \_\_\_\_\_.