Physical Science

SECTION 4.1

**Compound** – is a substance formed by a combination of elements, in a fixed proportion, and cannot be separated by physical means.

- A compound differs from a mixture.
- Compounds always contain the same elements in the same proportion.
- When elements combine to form a compound the resulting properties may be very different from those of the elements that make it.
- Unlike a mixture, a compound has a chemical formula that is always the same.

Each molecule of magnesium chloride, MgCl₂, contains
1 atom of magnesium
2 atoms of chlorine

Each molecule of glucose, C₆H₁₂O₆, contains
- 6 atoms of carbon
- 12 atoms of hydrogen
- 6 atoms of oxygen

- Molecules of a solid have the strongest attractions to one another.
- Molecules of a gas have the weakest attractions to one another.
- Molecules of a liquid have moderate attractions to one another.
- Gases take up a lot of space because their molecules have very little attraction for one another.
- Often atoms join so that each atom will have an outermost energy level that is full of electrons.
- The arrangement of atoms or ions within a substance is its chemical structure.

**Mixture** – is a substance consisting of two or more substances mixed together.

- Mixtures are not in fixed proportions and they are not held together by a chemical bond.
- Mixtures are different from compounds.
- Each substance in a mixture retains its own properties.

**Chemical bond** – is the attractive force that holds atoms or ions together.

- These forces hold different atoms or ions together.
- The bonds that hold atoms together behave most like flexible springs.
- Networks can be made of bonded atoms or ions.
- Atoms bond in compounds when their valence electrons interact.
- Atoms form bonds and fill their outermost energy levels in order to have an electronic arrangement similar to that of a noble gas.

**Chemical structure** – is the arrangement of bonded atoms or ions within a substance.

- When two hydrogen atoms bond, the positive nucleus of one atom attracts the negative electron of the other atom.

**Bond length** – is the average distance between the nuclei of two bonded atoms.

**Bond angle** – is the angle formed by two bonds to the same atom.
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**SECTION 4.2**

** Ionic bond** – is a bond formed by the attraction between oppositely charged ions.  
- Ionic compounds are melted or dissolved in water, moving ions can conduct electricity.  
- Sodium chloride, NaCl, is formed from a tight network of oppositely charged ions.  
- Solid ionic compounds have very high melting points.  
- High melting points are due to charged ions that are locked tightly together.  
- Positively charged ions are formed from metal elements.  
- Formula units of salt, NaCl, contain equal numbers of sodium ions and chloride ions.

**Polyatomic ion** – is an ion made of two or more atoms that are covalently bonded and that act like a single ion.  
- They are covalently bonded atoms that have either lost or gained electrons.  
- Their behavior resembles that of simple ions.

**Cation** – is a positively charged ion.  
Cation formed from sodium is called a sodium ion.  
Cation formed from potassium is called a potassium ion.

**Anion** – is a negatively charged ion.  
Anion formed from an oxygen atom is called an oxide ion.  
Anion formed from a chlorine atom is called a chloride ion.  
Anion formed from sulfur atom is called a sulfide ion.

**Naming Ionic Compounds**  
To name ionic compounds you have to recognize that the compound is ionic. An ionic compound consists of the combination of metal and nonmetal elements.

1. Name the cation (usually the metal ion) using the same name as the element. If the metal forms only one ion, a Stock number (Roman numeral) is not needed. For elements forming more than one ion, use the Stock number (a Roman numeral) following the element name. Do not put a space between the metal name and the Stock number. The Stock number is the same as the charge of the ion.
2. If the anion is monatomic, take the first syllable (sometimes two syllables) of the element name and use the prefix -ide. So O\(^{2-}\) becomes oxide, Cl\(^{-}\) becomes chloride, etc. Where more than one syllable of the element name is needed is usually obvious: I\(^{-}\) is iodide, Se\(^{2-}\) is selenide, etc. If the anion is polyatomic, use the name of the polyatomic ion.
3. The cation is always named first, followed by the anion.

4. Unless you are starting a sentence, names of compounds are not capitalized.
   1. NaBr - sodium bromide  
   2. CaSO\(_4\) - calcium sulfate  
   3. K\(_2\)S - potassium sulfide  
   4. Ni(NO\(_3\))\(_2\) - nickel(II) nitrate  
   5. Mg\(_3\)N\(_2\) - magnesium nitride  
   6. Fe\(_2\)(CO\(_3\))\(_3\) - iron(III) carbonate  
   7. Cr\(_2\)O\(_3\) - chromium(III) oxide  
   8. Ti(ClO\(_4\))\(_4\) - titanium(IV) perchlorate  
   9. AlCl\(_3\) - aluminum chloride  
   10. PbC\(_2\)O\(_4\) - lead(II) oxalate

Fe\(_2\)O\(_3\) is named iron (III) oxide because it contains Fe\(^{3+}\) ions.  
Copper (II) oxide, the charge of the copper ion is Cu\(^{2+}\).  
Nickel(III) fluoride, the charge of the nickel ion is Ni\(^{3+}\).
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**Metallic bond** – is a bond formed by the attraction between positively charged metal ions and the electrons around them.
- Atoms in metals are joined by metallic bonds.
- Metals conduct electricity because electrons can move from atom to atom.
- The nucleus of one atom is attracted by a nearby atom's electrons.
- Metals are good conductors of electricity.
- A metal’s electrons are free to move from atom to atom.

**Covalent bond** – is a bond formed when atoms share one or more pairs of electrons.
- Covalent bonds form when atoms share electron pairs.
- Electrons may be shared equally or unequally.
- Covalent bonds are formed between nonmetal atoms.
- Covalent bonds are formed from the sharing of electrons.
- A carbon atom can bond to four other atoms because it has four valence electrons.
- The structure of silicon dioxide consists of a network of atoms.

**Naming covalent compounds**

1. Name the first element in the compound as the element. If more than one of that element is found in the formula, use the appropriate prefix. Note that mono is never used as a prefix for the first element, when only one of that element is present.

   1. CO - carbon monoxide
   2. S\textsubscript{2}F\textsubscript{6} - disulfur hexafluoride
   3. N\textsubscript{2}O\textsubscript{4} - dinitrogen tetroxide
   4. P\textsubscript{4}O\textsubscript{10} - tetraphosphorus decoxide
   5. SeBr\textsubscript{2} - selenium dibromide
   6. CO\textsubscript{2} - carbon dioxide
   7. S\textsubscript{2}F\textsubscript{6} - disulfur hexafluoride
   8. Si\textsubscript{2}O\textsubscript{4} - silicon disulfide
   9. N\textsubscript{2}O\textsubscript{4} - dinitrogen tetrafluoride
   10. N\textsubscript{2}O\textsubscript{4} - dinitrogen tetrafluoride

2. Name the second element using the appropriate prefix to indicate how many and -ide suffix at the end of the name, just as if the element were a monatomic ion. If the element begins with a vowel, and the prefix ends with the letter a, drop the letter a in the prefix.

   1. CO - carbon monoxide
   2. CO\textsubscript{2} - carbon dioxide
   3. S\textsubscript{2}F\textsubscript{6} - disulfur hexafluoride
   4. P\textsubscript{4}O\textsubscript{10} - tetraphosphorus decoxide
   5. N\textsubscript{2}O\textsubscript{4} - dinitrogen tetroxide
   6. NCl\textsubscript{3} - nitrogen trichloride
   7. PBr\textsubscript{5} - phosphorus pentabromide
   8. Si\textsubscript{2}O\textsubscript{4} - silicon disulfide
   9. N\textsubscript{2}F\textsubscript{4} - dinitrogen tetrafluoride
   10. SeBr\textsubscript{2} - selenium dibromide

   **SECTION 4.3**

**Molecular formula** – is a chemical formula that reports the actual numbers of atoms in one molecule of a compound.

**Empirical formula** – is the simplest chemical formula of a compound that tells the smallest whole-number ratio of atoms in the compound.
- It is possible for different covalent compounds to have the same empirical formula because empirical formulas represent a ratio of atoms in the compound.
- Formaldehyde, CH\textsubscript{2}O, and acetic acid, C\textsubscript{2}H\textsubscript{4}O\textsubscript{2}, have the same empirical formula but different molecular formulas.

**Structural Formula**
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The structural formula for a water molecule is

● The melting and boiling points of quartz are very high because of the compound's structure.

SECTION 4.4

Organic compound – is any covalently bonded compound that contains carbon.
● Methane is the simplest organic compound.
● Carbon atoms form four covalent bonds in organic compounds.
● Starches and sugars are made of the elements carbon, hydrogen, and oxygen.
● Compound made of only carbon and hydrogen atoms are called hydrocarbons.
● Organic compounds almost always contain hydrogen.

Alkanes – are hydrocarbons that have only single covalent bonds only.
They follow the following formula: \#H = 2C + 2
Methane  CH₄
Propane   C₃H₈
Butane    C₂H₆
Pentane   C₅H₁₂
Hexane    C₆H₁₄
Heptane   C₇H₁₆
Octane    C₈H₁₈
Nonane    C₉H₂₀
Decane    C₁₀H₂₂

Alkenes – are hydrocarbons that have at least one double covalent bond between carbon atoms.
● They have the have carbon-carbon double bonds.

Alcohols – are organic compounds that are made of oxygen as well as carbon and hydrogen.
● Alcohols have hydroxyl, or –OH, groups.
● Alcohol molecules behave similarly to water molecules.
● Alcohols contain oxygen, carbon, and hydrogen.

Polymer – is a large organic molecule made of many smaller bonded units.
● Polymers form when small organic molecules bond to form long chains.
● They are large organic molecules that are made of repeating units.
● Some polymers are natural; others are man-made.
● The elasticity of a polymer is determined by its structure.
● Polymers are elastic because they are made of cross-linked chains.
● DNA is a polymer with a complex structure.
● DNA’s structure resembles a twisted ladder.
● In DNA, Cytosine, C, always pairs with Guanine, G.
● In DNA, Adenine, A, always pairs with Thymine, T.
● The "rungs" of the DNA "ladder" are made up of paired monomers.
● DNA can copy itself because it is made of two strands that can be separated.

Protein – is a biological polymer made of bonded amino acids.
● Proteins are polymers of amino acids

Biochemical compound – is any organic compound that has an important role in living things.
● Biochemical compounds are polymers important to living things.
Carbohydrate – is any organic compound that is made of carbon, hydrogen, and oxygen and that provides nutrients to the cells of living things.

Many carbohydrates are made of glucose.

Amino acid – is any one of 20 different naturally occurring organic molecules that combine to form proteins.