*Use the class notes (and/or textbook) to complete this study guide.*

**Ionic Bonding and Ionic Compounds**

**I\_\_\_\_** are electrically charged particles formed when atoms gain or lose **\_\_\_\_\_.** Once formed, ions have the same electron configurations as the **\_\_\_\_\_** gases.

**M\_\_\_\_\_** atoms form **\_\_\_\_\_** ions, while **\_\_\_\_\_** -metal atoms form **\_\_\_\_\_** ions. The strong [**ELECTROSTATIC**](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atomic/ionicrev1.shtml) forces of attraction between **OPPOSITELY** charged ions are called **\_\_\_\_\_** bonds.

* Metal atoms **\_\_\_\_\_** the electron, or electrons, in their **\_\_\_\_\_** energy level and become positively charged **\_\_\_\_\_.**
* Non-metal atoms **\_\_\_\_\_** an electron, or electrons, from another atom to become negatively charged **\_\_\_\_\_**.

|  |  |
| --- | --- |
| Draw the charged sodium & aluminum ions | Draw the charged oxide & chloride ions |

Make electron dot diagrams for the atoms. Show the charge of the cations produced.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lithium Atom | Lithium Ion |  | Sodium Atom | Sodium Ion |
|  |  |  |  |  |
|  |  |  |  |  |
| Magnesium Atom | Magnesium Ion |  | Calcium Atom | Calcium Ion |
|  |  |  |  |  |

Lithium is in Group \_\_\_A. It has \_\_\_ electron in its highest energy level. When this electron is \_\_\_\_\_, a lithium \_\_\_\_\_ (Li+) is formed.

Sodium is also in Group \_\_\_ A. It has \_\_\_ electron in its highest energy level. When this electron is \_\_\_\_\_, a sodium \_\_\_\_\_ (Na+) is formed. Note that a sodium ion has the same electron configuration as a NEON atom (noble gas, group VIIIA).

Magnesium is in Group \_\_\_ A. It has \_\_\_ electrons in its highest energy level. When these electrons are \_\_\_\_\_, a magnesium CATION (Mg2+) is formed. A magnesium ion has the same electron configuration as a NEON atom (NOBLE gas, group VIIIA).

Calcium is also in Group \_\_\_ A. It has \_\_\_ electrons in its highest energy level. When these electrons are \_\_\_\_\_, a calcium \_\_\_\_\_ (Ca2+) is formed. A calcium ion has the same electron configuration as an ARGON atom (noble gas, group VIIIA).

**NON-Metals**: Make electron dot diagrams for the atoms. Show the charge of the anions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fluorine Atom F | Fluoride Ion F- |  | Neon Atom Ne |  |
|  |  |  |  | Notice Neon has no charge |
|  |  |  |  |  |
| Chlorine Atom Cl | Chloride Ion Cl- |  | Oxygen Atom O | Oxide Ion O-2 |
|  |  |  |  |  |

Fluorine is in Group \_\_\_ A. It has \_\_\_ electrons in its highest energy level. It \_\_\_\_\_ an electron from another atom in reactions, forming a fluoride \_\_\_\_\_, F-. Note that the atom is called fluorine, but the ion is called \_\_\_\_\_. Note that a fluoride ion has the same electronic structure as a NEON atom (noble gas, group VIIIA).

Chlorine is in Group \_\_\_ A. It has \_\_\_ electrons in its highest energy level. It \_\_\_\_\_ an electron from another atom in reactions, forming a chloride \_\_\_\_\_, Cl-.

Oxygen is in Group \_\_\_ A. It has **\_\_\_**  electrons in its highest energy level. It **\_\_\_\_\_** two electrons from one or two other atoms in reactions, forming an oxide **\_\_\_\_\_**, O2-.

* When metals react with non-metals, electrons are **\_\_\_\_\_** from the metal atoms to the non-metal atoms, forming \_\_\_\_\_. The resulting compound is called an \_\_\_\_\_ compound. In each of these reactions, the metal atoms give electrons to the non-metal atoms, so that the metal atoms become \_\_\_\_\_ cations and the non-metal atoms become \_\_\_\_\_ anions. There is a strong ELECTROSTATIC force of attraction between these oppositely-charged ions, called an **\_\_\_\_\_ bond**.

Draw the electron dot diagram before bonding:

|  |  |  |
| --- | --- | --- |
| Ionic Compound | Before | After |
| Sodium chloride  NaCl |  | **NaCl** |
| Magnesium Oxide  MgO |  |  |
| Calcium Chloride  CaCl2 | **CaCl2** | |

There are many ionic bonds in an ionic compound such as sodium chloride, arranged in giant ­­­­**LATTICE** structures. Ionic compounds have **\_\_\_\_\_** melting and boiling points.

Ionic **\_\_\_\_\_** do NOT conduct electricity (no free moving ions). They do conduct current when melted (liquid state), vaporized (gaseous state), or **\_\_\_\_\_** in water because ions can flow fleely.

Metals tend to have **\_\_\_\_\_ (**low/high**)**) ionization energies because they tend to **\_\_\_\_\_** electrons. Nonmetals tend to have **\_\_\_\_\_ (**low/high) electronegativities because they tend to **\_\_\_\_\_** electrons.

**Covalent Bonding**

A covalent bond is when two atoms **\_\_\_\_\_** (transfer/share) a pair of electrons. Covalent bonds occur most between **\_\_\_\_\_** (metallic/non-metallic) elements. Electrons are shared in the outermost **\_\_\_\_\_**. Covalently bonded substances consist of small molecules, which are a group of two or more atoms joined together by sharing their **\_\_\_\_\_**. Substances that are made up of ions do not form molecules, but only compounds as part of **\_\_\_\_\_** bonds.

Atoms generally exist in their lowest energy state in order to become **\_\_\_\_\_**. Two conditions of atomic stability are **\_\_\_\_\_**  **\_\_\_\_\_** and a **\_\_\_\_\_ \_\_\_\_\_**. Stability drives atoms to bond.

Covalent bonds are often represented by an electron dot diagram. Draw the end product of the covalent bond for HCl:

After bonding, the chlorine atom, as most atoms, is now in contact with **\_\_\_\_\_** electrons in its highest energy level orbitals or **\_\_\_\_\_**; so it is STABLE. The hydrogen atom is now in contact with **\_\_\_\_\_** electrons in its highest energy level orbital or valence; so the hydrogen atom is also **\_\_\_\_\_**. Hydrogen and Chlorine share a single **\_\_\_\_\_** of electrons.

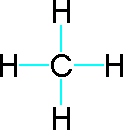
Most non-metallic atoms can form multiple covalent bonds; that is, share not just one pair of electrons but two or more pairs. Atoms of different elements will form either one bond (one **\_\_\_\_\_** of shared electrons, two bonds (**\_\_\_\_\_** pairs of shared electrons), three bonds (three pairs of **\_\_\_\_\_** electrons), or four covalent bonds (**\_\_\_\_\_** pairs of shared electrons) with other atoms.

Covalent bonds can be polar or non-polar. This is based on how electrons are shared. **\_\_\_\_\_** bonds mean that electrons are shared **\_\_\_\_\_** between atoms of the same element. e.g. Professor HOFBrINCl elements.

Bonding elements: A ↔ A or B ↔ B

**P\_\_\_\_\_** bonds mean that Electrons are shared **\_\_\_\_\_** between atoms. One atom draws the electrons more than the other. Bonding elements: A ↔ B

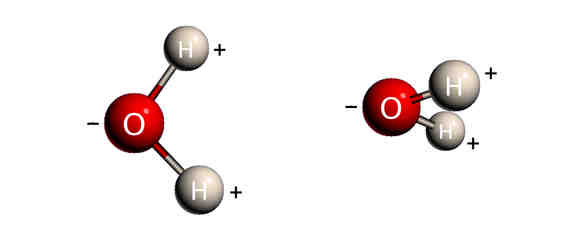
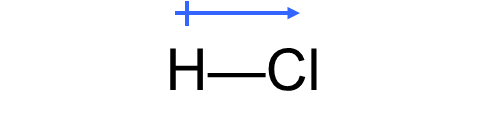
Covalent **\_\_\_\_\_** may be polar or non-polar depending on the distribution of electrons. Non-polar molecules share electrons **\_\_\_\_\_** throughout the molecule and have geometrically **\_\_\_\_\_** (balanced) shapes. E.g. CO2, CH4, BF3, BeF2. Examples:

BF3

F−Be−F

All **\_\_\_\_\_** diatomic elements are **\_\_\_\_\_** molecules as well as molecules whose overall polarity cancels out.

**P\_\_\_\_\_** molecules share electrons unequally throughout the molecule. A partial **\_\_\_\_\_** pole exists closer to one atom(s) and a partial **\_\_\_\_\_** pole exists closer to the other atom(s). Examples: HF, H2O.

**Structural Formulas**

A structural formula shows the bonds between atoms in a molecule. Straight lines or dashes are the most common way to represent covalent bonds, with each line representing a shared pair of electrons.



Using the electron dot diagram: the shared pair becomes one dash or straight line. Draw or type it: H–Cl.

.

Write the electron dot diagram (bottom box) and the structural formula (SF) for each molecule shown, given the molecular formula (MF):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Hydrogen** | | **Water** | | **Ammonia** | | **Methane** | |
| MF | SF | MF | SF | MF | SF | MF | SF |
| H2 |  | H2O |  | NH3 |  | CH4 |  |
|  | |  | |  | |  | |

All the bonds shown are called single covalent bonds because only **\_\_\_\_\_** of electrons is shared between two atoms. Notice that hydrogen only form **\_\_\_\_\_** covalent bond, oxygen can form **\_\_\_\_\_** bonds, nitrogen can form **\_\_\_\_\_** bonds, and carbon can form **\_\_\_\_\_** bonds.

**Some Molecules contain more than one pair of shared electrons between two atoms. For instance,** a molecule of of oxygen (**O2**) consists of **\_\_\_\_\_** oxygen atoms held together by a double bond which contains **\_\_\_\_\_** of shared electrons and is represented by **\_\_\_\_\_** dashes between the two atoms. A molecule of nitrogen (**N2**) consists of **\_\_\_\_\_** nitrogen atoms held together by a triple bond which contains **\_\_\_\_\_** of shared electrons and is represented by **\_\_\_\_\_** dashes between the two atoms.

Given the Molecular Formulas (in the left box), draw the electron dot diagram (middle box) and Structural Formula for each molelcule.

|  |  |  |
| --- | --- | --- |
| Hydrogen atoms  in a **single** bond  H2 |  | Write the  “Structural Formula” |
| Oxygen atoms  in a **double** bond  O2 |  | Write the  “Structural Formula” |
| Nitrogen atoms  in a **triple** bond  N2 |  | Write the  “Structural Formula” |

Note that molecules with a double **covalent bond possess** **\_\_\_\_\_** shared **\_\_\_\_\_** of electrons. A double covalent bond is shown by **\_\_\_\_\_** dashes in the structural formula between two atoms.

Molecules with a triple **covalent bond possess** **\_\_\_\_\_** shared **\_\_\_\_\_** of electrons. A triple covalent bond is shown by **\_\_\_\_\_** dashes in the structural formula between two atoms.

Answers

*Use the class notes (and/or textbook) to complete this study guide.*

**Ionic Bonding and Ionic Compounds**

**IONS** are electrically charged particles formed when atoms gain or lose **ELECTRONS.** Once formed, ions have the same electron configurations as the **NOBLE** gases.

**METAL** atoms form **POSITIVE** ions, while **NON**-metal atoms form **NEGATIVE** ions. The strong [**ELECTROSTATIC**](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atomic/ionicrev1.shtml) forces of attraction between **OPPOSITELY** charged ions are called **IONIC** bonds.

* Metal atoms **LOSE** the electron, or electrons, in their **HIGHEST** energy level and become positively charged **CATIONS.**
* Non-metal atoms **GAIN** an electron, or electrons, from another atom to become negatively charged **ANIONS**.

|  |  |
| --- | --- |
| Draw the charged sodium & aluminum ions  Na+ Al+3 | Draw the charged oxide & chloride ions  O-2 Cl-1 |

Make electron dot diagrams for the atoms. Show the charge of the cations produced.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lithium Atom | Lithium Ion |  | Sodium Atom | Sodium Ion |
|  | Li+ |  |  | Na+ |
|  |  |  |  |  |
| Magnesium Atom | Magnesium Ion |  | Calcium Atom | Calcium Ion |
|  | Mg+2 |  |  | Ca+ |

**Lithium** is in Group **IA.** It has **1** electronin its highest energy level. When this electron is **lost**, a lithium **cation** (Li+) is formed.

**Sodium** is also in Group **IA**. It has **1** electron in its highest energy level. When this electron is **LOST**, a sodium **CATION** (Na+) is formed. Note that a sodium ion has the same electron configuration as a **NEON2** atom (noble gas, group VIIIA).

**Magnesium** is in Group **IIA**. It has **2** electrons in its highest energy level. When these electrons are **LOST**, a magnesium **CATION** (Mg2+) is formed. A magnesium ion has the same electron configuration as a **NEON** atom (**NOBLE** gas, group VIIIA).

**Calcium** is also in Group **IIA**. It has **2** electrons in its highest energy level. When these electrons are **LOST**, a calcium **CATION** (Ca2+) is formed. A calcium ion has the same electron configuration as an **ARGON** atom (noble gas, group VIIIA).

**NON-Metals**: Make electron dot diagrams for the atoms. Show the charge of the anions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fluorine Atom F | Fluoride Ion F- |  | Neon Atom Ne |  |
|  | F- |  |  | Notice Neon has no charge |
|  |  |  |  |  |
| Chlorine Atom Cl | Chloride Ion Cl- |  | Oxygen Atom O | Oxide Ion O-2 |
|  | Cl- |  |  | O-2 |

**Fluorine** is in Group **VIIA**. It has **7** electrons in its highest energy level. It **GAINS** an electron from another atom in reactions, forming a fluoride **ANION**, F-. Note that the atom is called fluorine, but the ion is called **FLUORIDE**. Note that a fluoride ion has the same electronic structure as a **NEION** atom (noble gas, group **VIIIA**).

**Chlorine** is in Group **VIIA**. It has **7** electrons in its highest energy level. It **GAINS** an electron from another atom in reactions, forming a chloride **ANION**, Cl-.

**Oxygen** is in Group **VIA**. It has **6** electrons in its highest energy level. It **GAINS** two electrons from one or two other atoms in reactions, forming an oxide **ANION**, O2-.

* When metals react with non-metals, electrons are **TRANSFERRED** from the **METAL** atoms to the **NON-METAL** atoms, forming **IONS**. The resulting compound is called an **IONIC COMPOUND**. In each of these reactions, the metal atoms give electrons to the non-metal atoms, so that the metal atoms become **POSITIVE** cations and the non-metal atoms become **NEGATIVE** anions. There is a strong **ELECTROSTATIC** force of attraction between these **OPPOSITELY**-charged ions, called an **IONIC bond**.

Draw the electron dot diagram before bonding:

|  |  |  |
| --- | --- | --- |
| Ionic Compound | Before | After |
| Sodium chloride  NaCl |  | **NaCl** |
| Magnesium Oxide  MgO |  |  |
| Calcium Chloride  CaCl2 | **CaCl2** | |

There are many ionic bonds in an ionic compound such as sodium chloride, arranged in giant ­­­­**LATTICE** structures. Ionic compounds have **HIGH** melting and boiling points.

Ionic **SOLIDS** do NOT conduct electricity (no free moving ions). They do conduct current when melted (liquid state), vaporized (gaseous state), or **DISSOLVED** in water because ions can flow fleely.

Metals tend to have **LOW** ionization energies because they tend to **LOSE** electrons. Nonmetals tend to have **HIGH** electronegativities because they tend to **GAIN** electrons.

**Covalent Bonding**

A covalent bond is when two atoms **SHARE** (transfer/share) a pair of electrons. Covalent bonds occur most between **NON-METALLIC** (metallic/non-metallic) elements. Electrons are shared in the outermost **ENERGY LEVEL**. Covalently bonded substances consist of small molecules, which are a group of two or more atoms joined together by sharing their **VALENCE**. Substances that are made up of ions do not form molecules, but only compounds as part of **IONIC** bonds.

Atoms generally exist in their lowest energy state in order to become **STABLE**. Two conditions of atomic stability are **ELECTRICAL NEUTRALITY** and a **FULL VALENCE**. Stability drives atoms to bond.

Covalent bonds are often represented by an electron dot diagram. Draw the end product of the covalent bond for HCl:



After bonding, the chlorine atom, as most atoms, is now in contact with **EIGHT** electrons in its highest energy level orbitals or **VALENCE**; so it is STABLE. The hydrogen atom is now in contact with **TWO** electrons in its highest energy level orbital or valence; so the hydrogen atom is also **STABLE**. Hydrogen and Chlorine share a single **PAIR** of electrons.

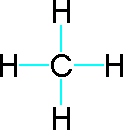
Most non-metallic atoms can form multiple covalent bonds; that is, share not just one pair of electrons but two or more pairs. Atoms of different elements will form either one bond (one **PAIR** of shared electrons, two bonds (**TWO** pairs of shared electrons), three bonds (three pairs of **SHARED** electrons), or four covalent bonds (**FOUR** pairs of shared electrons) with other atoms.

Covalent bonds can be polar or non-polar. This is based on how electrons are shared. **NON-POLAR** bonds mean that electrons are shared **EQUALLY** between atoms of the same element. e.g. Professor HOFBrINCl elements.

Bonding elements: A ↔ A or B ↔ B

**POLAR** bonds mean that Electrons are shared **UNEQUALLY** between atoms. One atom draws the electrons more than the other. Bonding elements: A ↔ B

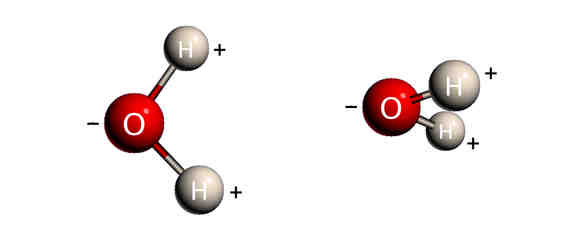
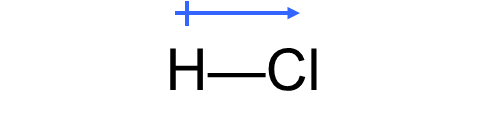
Covalent **MOLECULES** may be polar or non-polar depending on the distribution of electrons. Non-polar molecules share electrons **EQUALLY** throughout the molecule and have geometrically **SYMMETRICAL** (balanced) shapes. E.g. CO2, CH4, BF3, BeF2. Examples:

BF3

F−Be−F

All **HOFBrINCl** diatomic elements are **NON-POLAR** molecules as well as molecules whose overall polarity cancels out.

**POLAR** molecules share electrons unequally throughout the molecule. A partial **NEGATIVE** pole exists closer to one atom(s) and a partial **POSITIVE** pole exists closer to the other atom(s). Examples: HF, H2O.

**Structural Formulas**

A structural formula shows the bonds between atoms in a molecule. Straight lines or dashes are the most common way to represent covalent bonds, with each line representing a shared pair of electrons.



Using the electron dot diagram: the shared pair becomes one dash or straight line. Draw or type it: H–Cl.

.

Write the electron dot diagram (bottom box) and the structural formula (SF) for each molecule shown, given the molecular formula (MF):

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Hydrogen** | | **Water** | | **Ammonia** | | **Methane** | |
| MF | SF | MF | SF | MF | SF | MF | SF |
| H2 |  | H2O |  | NH3 |  | CH4 |  |
|  | |  | |  | |  | |

All the bonds shown are called single covalent bonds because only **ONE PAIR** of electrons is shared between two atoms. Notice that hydrogen only form **ONE** covalent bond, oxygen can form **TWO** bonds, nitrogen can form **THREE** bonds, and carbon can form **FOUR** bonds.

**Some Molecules contain more than one pair of shared electrons between two atoms. For instance,** a molecule of of oxygen (**O2**) consists of **TWO** oxygen atoms held together by a double bond which contains **TWO PAIRS** of shared electrons and is represented by **TWO** dashes between the two atoms. A molecule of nitrogen (**N2**) consists of **TWO** nitrogen atoms held together by a triple bond which contains **THREE PAIRS** of shared electrons and is represented by **THREE** dashes between the two atoms.

Given the Molecular Formulas (in the left box), draw the electron dot diagram (middle box) and Structural Formula for each molelcule.

|  |  |  |
| --- | --- | --- |
| Hydrogen atoms  in a **single** bond  H2 |  | Write the  “Structural Formula” |
| Oxygen atoms  in a **double** bond  O2 |  | Write the  “Structural Formula”  **0 = 0** |
| Nitrogen atoms  in a **triple** bond  N2 |  | Write the  “Structural Formula” |

Note that molecules with a double **covalent bond possess** **TWO** shared **PAIRS** of electrons. A double covalent bond is shown by **TWO** dashes in the structural formula between two atoms.

Molecules with a triple **covalent bond possess** **THREE** shared **PAIRS** of electrons. A triple covalent bond is shown by **THREE** dashes in the structural formula between two atoms.