MS1 & 2: Lesson 2

Outcome: *Examine the role of valence electrons in the formation of chemical bonds*
Indicators:

- Explain the formation of ions and predict their charge in group 1 and 2 elements and non-metals, based on an understanding of valence electrons and the octet rule.
- Draw Lewis structures (electron dot structures) for group 1 and 2 elements and non-metals, based on an understanding of valence electrons.
- Discuss the role of valence electrons in the formation of covalent and ionic bonds, including the connection to metals and non-metals. (K)
- Predict the arrangement of atoms and draw Lewis structures (electron dot structures) to represent covalent- and ionic-bonded molecules. (S)

Intramolecular Forces

- Intra" is latin for "_____".
- Intramolecular forces are forces **within** a molecule or compound holding it **together.**
- Atoms want to have a full valence shell, because then they will be stable. Atoms can fill or empty their valence shell by sharing, gaining or losing **electrons**.
- There are three types of intramolecular forces we will discuss: _____ bonding, _____ bonding and _____ bonding.

1. Metallic Bonds

Formation of metallic bonds

- Metals are made up of _____ with loosely held valence electrons.
- The valence electrons of a pure metal can be modeled as a "_____" of electrons.
- The electrons are able to _____ freely from one part of the metal to another.
- Metallic bonds are the forces of attraction between free floating valence electrons and the positively charged metal ions.

Properties of Metals:

- The "sea of electrons" can help to explain the properties of metals.
- Good conductors of electricity
    - because charges (electrons) can _____in the metal.
- Metals are ductile (can be drawn into wires) and malleable (bendable/moldable)
    - because the metal cations are surrounded by electrons ("sea") so when force is applied, the electrons act as a _____ or insulator preventing the positively charged ions from getting too close. This means protons will not repel to cause breaking but rather move and glide around one another allowing the metal to _____.
- Metals form crystalline structures
    - because they are made of _____ which naturally like to have a close packed arrangement (similar to how fruit stacks at the grocery store).

Alloys

- Alloys are a mixture of two or more elements where at least one of those elements is a metal.
- Alloys often have better properties than the metals that make them up
- Ex. Sterling silver (92.5% silver and 7.5% copper) is harder and more durable than pure silver, but still soft enough to make jewelry or silverware.
- Steels are important alloys with a wide range of useful properties such as corrosion resistance, ductility, hardness, and toughness.

2. Ionic Bonding

- One way an atom will _____it's valence shell is through ionic bonding (creating ions)
- Ionic bonding occurs when a _____ bonds with a _____
- Ionic bonding occurs when there is a complete _____ of one or more electrons from one atom to another.
- You can predict the _____ of the ion created through ionic bonding based on the number of valence electrons it contains. (**remember electrons are negatively charged)**

Element	**Number of Valence e-**	**e- gain/lose to fill octet**	**Charge with full valence**
Oxygen			
Sodium			
Hydrogen			

Formation of Ions:

- When an atom loses or gains electrons it forms an_____(this is ionic bonding).
- An ion is an atom or group of atoms with an overall _____ or _____ charge.
- Usually atoms on the left of the staircase (metals) _____ electrons, forming _____ with a _____charge.
- Atoms on the right of the staircase (non-metals) tend to _____ electrons, forming _____ with a _____ charge.
- The cations and anions combine together in a ratio that _____ their charge
- Since cations and anions have opposite charges, they are _____ to each other. This attraction, called electrostatic force, holds them together in an ionic bond.

- An atom and an ion are very different.
    - Example: Some differences in chemical and physical properties for sodium ion and sodium atom.

Property	Na atom	Na^+ ion
charge	neutral (0)	positive (+1)
pure form	soft, shiny metal	not found pure; must be combined with anions to form stable ionic compounds
reaction with water	violent exothermic reaction with water forms $Na^+(aq)$, $OH^-(aq)$, $H_2(g)$	Na^+ dissolves in water without further reaction
conductivity	Na(s) is an excellent conductor of heat and electricity	Na^+ solid compounds are poor conductors of heat and electricity; Na^+ in aqueous solution conducts electricity

Elements with multiple ionic charges:

- _____ elements are ones that can form more than one stable ion. Most _____ metals are multivalent.
- Multivalent elements are ones that occur on your common ion sheet _____ (ex. Copper, iron, tin)
- When naming elements containing these compounds we use _____ _____to distinguish which ion is used.

Polyatomic ions:

- _____.
- Polyatomic ions often have complicated sounding names which makes them seem dangerous or synthetic but many poyatomic ions occur naturally.

Lewis Dot diagrams for ions

1. Determine the number of _____ the ion has (look at how many the neutral atom would have and how many electrons were gained or lost based on the charge).
2. Draw your lewis dot structure
3. Place _____around the diagram with the charge outside the bracket in the top right corner.

Examples:

K + As^{3-}

Valence Electron, Ions & Lewis dot Assignment (complete all columns)

Lewis dot for the Formation of Ionic Bonds:

- Example: Sodium Chloride
    - Sodium has 1 valence electron and would like to lose one, chloride has 7 valence electrons and would like to gain one, so an ionic bond will occur where one sodium atom will give it's valence electron to a chlorine, making the sodium have a +1 charge and chlorine/chloride have a -1 charge. Since the atoms are now a cation and an anion, they are attracted to one another.

- Lewis drawing:

- Not all ionic compounds are created from cations and anions with a 1:1 ratio.
- Example: Aluminum Bromide
  - Lewis Drawing:

See Ionic Compound Lewis Assignment

RECALL FROM PREVIOUS STUDIES

CHEMICAL FORMULA:

- To determine the chemical formula of a compound you look at charges and determine what the lowest number ratio the cation and anion could pair up in to cancel their charges.
- Remember subscripted numbers indicate the number of atoms/ions present.
- The cation should always be written first followed by the anion.
  - Ex: Aluminum sulfide
- If a compound contains a polyatomic ion where more than one is present, parenthesis are used to indicate how many polyatomic ions there are.
  - Ex. Calcium phosphate
- If using criss cross method, remember to always reduce. Ionic compounds are written as formula units which is the whole number ratio of ions.
  - Ex. Barium sulfate

NAMING:

- To name a binary ionic compound simply write the name of the metal and then the name of the nonmetal with and "ide" ending (subscripted numbers do not need to be included in the name as long as there is only one possible charge).
  - Ex. $MgBr_2$
- To name ions containing a polyatomic ion, simply write the name of the cation and then the name of the anion (do not need to change the endings).
  - Ex. Na_3PO_4
- If you are naming a compound with a multivalent element, use roman numerals to indicate which ion is present.
  - Ex. $FePO_4$

https://www.youtube.com/watch?v=U7wavimfNFE

Structure of Ionic Compounds:

- Looking at the structure of ionic compounds can help us to understand their _____
- Ionic compounds form rigid arrangements of ions called a _____
- Different sized ions pack together to form different _____ crystals
- An ionic compound contains a huge number of positive and negative ions in a fixed ratio (_____).

Properties:

- _____solids at room temperature
    - because their bonds resist being stretched
- _____ melting and boiling points
    - because they are held together by strong electrostatic forces (ionic bonds)
- Crystals made of ionic compounds can be easily _____
    - because when an outside force strikes a crystal it can offset the lattice making positively charged particles sit next to other positively charged particles. Since positives repel one another the crystal breaks.
- Conduct electricity when _____ (molten) but not as _____.
    - When molten the ions are able to move around and carry charges (conduct electricity).
- Conduct electricity when _____.
    - When dissolved in water, water pulls the ions out of the crystalline lattice. Since they are then able to move about freely, they can then carry a charge and conduct electricity.

3. Covalent Bonds

- Another way for atoms to fill their valence shell is through _____
- Covalent bonding occurs between a _____and a _____.
- Covalent bonding occurs when electrons are _____ between two atoms.
- Covalent bonds can occur as single, double or triple bonds
    - Single bonds occur when _____ pair of electrons is shared between two atoms (each atom donating 1 electron to share)
    - Double bonds occur when _____ pairs of electron are shared between two atoms (each atom donating two electrons to share)
    - Triple bonds occur when _____ pairs of electrons are shared between two atoms (each atom donating three electrons to share)
- You can predict the number of covalent bonds needed based on the number of valence electrons an atom contains. (**remember electrons are negatively charged)**

Element	Number of Valence e-	e- needed to fill octet	Possible bonds created
Oxygen			
Nitrogen			
Carbon			

Molecules and Molecular Compounds

- A molecule is a neutral group of atoms _____ together through covalent bonds.
- Noble gases have full valence shells naturally so they are the only _____ elements.
- There are 7 diatomic elements that occur in pairs in nature: _____.
- Determining the chemical formula of a molecule is more difficult than with an ionic compound because there can be _____ compounds possible for the same two elements depending on the types of bonds that form.
- Unlike ionic compounds, covalent molecules molecular formula is not _____ to the lowest ratio. It represents the exact number of atoms that combine to form exactly one molecule.

Lewis Dot for the Formation or Molecular Compounds

- When given the chemical formula, you can use lewis dot structures to represent the bonding and show the structural formula for a molecule.
- Start by drawing out the lewis dot for each of the atoms involved. Then determine where the electrons will share in order for all atoms to bond together
- If you have a chemical formula where there is one atom of one element and several atoms of a different element, usually the element with one atom is in the middle surrounded by the others.
    - Ex: F_2

- Ex. HCN

- Ex. NH_3 Notice that an unshared pair can affect the shape of the molecule.

See Covalent Bonding Lewis Dot Assignment

RECALL FROM PREVIOUS STUDIES

NAMING MOLECULES:

- **Binary compounds**: These are compounds that contain only _____. When naming binary compounds we use _____ to indicate the amount of each element present.

1	2	3	4	5	6	7	8	9	10
Mono*	di	tri	tetra	penta	hexa	hepta	octa	nona	deca

*Mono is only used for the second element in a compound.

Ex. CO_2

P_4O_{10}

CF_4

CHEMICAL FORMULA:

Use the prefix to determine the number of each element and then write it down:

Dinitrogen trioxide

Diphosphorus pentoxide

Name:_____

Ionic Compound Lewis Assign:

Use the Lewis formulas for atoms to determine which ions and ionic compounds will form when the following elements combine:

1. Lithium and Fluorine

2. Calcium and chlorine

3. Magnesium and oxygen

4. Aluminum and iodine

5. Calcium and phosphorus

6. Sodium and nitrogen

7. Why do nonmetal atoms tend to form anions when they react to form compounds?

Name:_____

Covalent and Ionic Bonding Assignment

Classify the following compounds as ionic (metal + non-metal), covalent (non-metal + non-metal) or both (compound containing a polyatomic ion), then name the compound using IUPAC naming rules.

1. $CaCl_2$ _____

2. CO_2 _____

3. H_2O _____

4. $BaSO_4$ _____

5. K_2O _____

6. NaF _____

7. Na_2CO_3_____

8. CH_4 _____

9. SO_3 _____

10. LiBr _____

Name:_____

Covalent Bonding Lewis Dot Assignment

Draw the lewis dot structure for the covalent molecules created from the elements below. Be sure to draw the lewis dot in 2 steps, to show how the electrons are involved in bonding.

1. H_2

2. O_2

3. N_2

4. CO_2

5. H_2O

6. HNO_3

7. Explain why neon is monatomic but chlorine is diatomic.