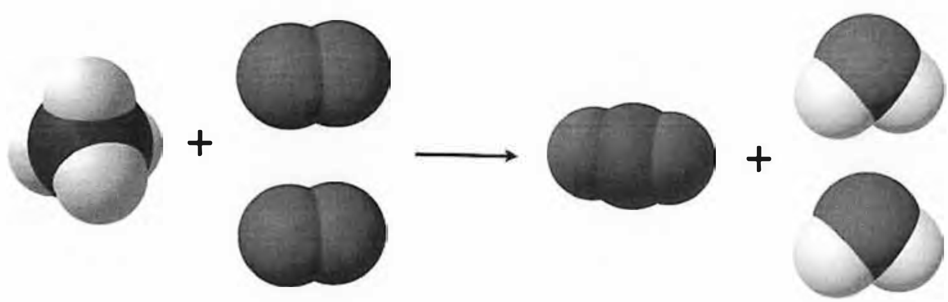
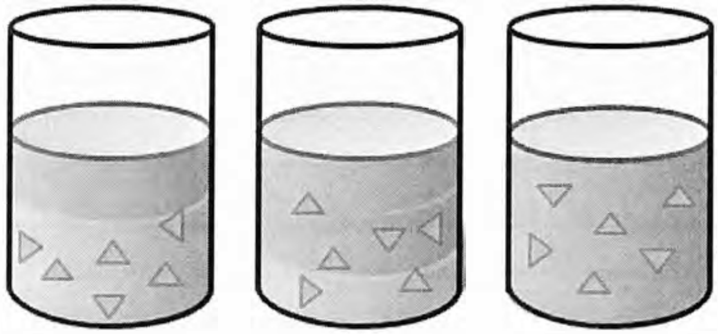
Chemical Reaction for All Life Forms



$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

[M2U2]

Module 2, Unit 2: Chemical Reactions
Lesson 1: Does it Dissolve?



HS-ESS2-5: Plan and conduct an investigation of properties of water and its effects on Earth materials and surface processes.

SEP	DCI	CCX
Planning and Carrying Out Investigation	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting point of rocks.	**Structure and Function**

Goals: Water is one of the most amazing substance on Earth. It can bring life as well as death. In this lesson, students will be able to explain and describe one of the properties of water: dissolving ability using the idea of like dissolve like in their report.

Activity:

Materials:

- Triple beam balance or electronic balance
- Compounds:
  - Sea water (liquid)
  - Water (liquid)
  - Vinegar (liquid)
  - Sugar (solid)
  - Shaved crayons/paraffin/Shaved candles (solid)
  - Cooking oil (liquid)
  - Acetone (liquid)
  - Isopropyl Alcohol (liquid)

Procedure:

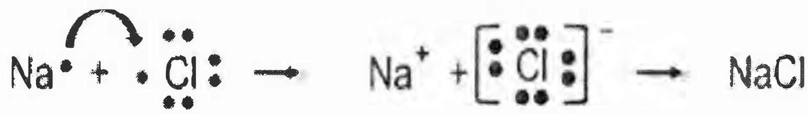
1) Group discussion:
   a) What is a solute?
   b) What is a solvent?
   c) What is a solution?

2) Measure out a small amount of each compound and mix them. Record the result in the table below:

	Sea water	Water	Vinegar	sugar	Cooking oil	acetone	crayons	IPA
Sea water								
water								
vinegar								
sugar								
Cooking oil								
acetone								
crayons								
IPA								

3) Group discussion:
   a) Based on your solubility table, group the compounds into two groups
   b) Why do you group those compounds in the same group? What properties do they have that allowed them to dissolved each other?

To Bond or Not to Bond - Part 1



Activity

Why do atoms want to bond? It's because of the "octet rule": all elements want to obtain eight electrons to become stable. There are two main types of bonds: ionic and covalent. In ionic bonding, atoms gain or lose valence electrons in order to form a bond. Ionic bonding always occurs between metals and nonmetal atoms. For covalent bonds, all elements want eight electrons with the exception of hydrogen. They achieve this by sharing electrons. Covalent bonds only occur between nonmetals and are weaker than ionic bonds. Electron dot formulas can represent both types of bonding.

Procedure

Part 1: Bonding 3D Graphic Organizer

1. Obtain all materials and bonding cutout from your teacher.
2. Take the piece of construction paper and place it in a landscape orientation.
3. Fold it in half vertically. Then unfold so there is a crease down the center of the paper. Now, create two more folds by folding each half to the center fold line made in Step 3. This is called a "shutter fold." There should be two vertical flaps when looking at the front of the construction paper.
4. Divide the two side shutter flaps into two equal sections by making a horizontal cut that goes to the fold on each side, making a total of four flaps.
5. Across the top flaps write, "Ionic Bond."
6. Across the bottom flaps write, "Covalent Bond."
7. Cut the Bonding Cards apart.
8. Open the flaps, and on the left side, glue the electron dot diagram of a compound that represents each type of bond.
9. Make sure that the diagram is glued on the flap with the correct label.
10. In the middle section, glue the definition of the bond type.
11. On the right side, glue in the examples of compounds that represents each type of bond.
12. After completion of the 3D Graphic Organizer, please identify each of the following as an ionic or covalent bond:

a. K – Br Ionic or Covalent
b. S – O Ionic or Covalent
c. Si – Cl Ionic or Covalent
d. H – F Ionic or Covalent
e. Se – S Ionic or Covalent
f. H – O Ionic or Covalent
g. Na – Cl Ionic or Covalent
h. Cs – S Ionic or Covalent
i. H – N Ionic or Covalent
j. Ca – I Ionic or Covalent
k. Al – O Ionic or Covalent
l. Mg – Br Ionic or Covalent

To Bond, or Not to Bond

Student Reference Sheet: Ionic Compounds

Li^{+}	Br^{-}	$LiBr$
Na^{+}	Cl^{-}	$NaCl$
K^{+}	S^{2-}	K_2S
Be^{2+}	I^{-}	BeI_2
Mg^{2+}	O^{2-}	MgO
K^{+}	I^{-}	Ca^{2+}
Ca^{2+}	P^{3-}	Ca_3P_2
Al^{3+}	F^{-}	AlF_3
Ca^{2+}	P^{3-}	F^{-}
F^{-}		

To Bond, or Not to Bond

Student Reference Sheet: Student Cutout

A chemical bond formed in which one or more valence electron pairs are shared between two atoms.	$[\mathrm{Na}]^{+}[:\underset{\cdot\cdot}{\ddot{\mathrm{Cl}}}:]^{-}$
A chemical bond occurs from the attraction of cations and anions which causes electrons to be transferred from one atom to another.	**H:H**

To Bond, or Not to Bond

Student Reference Sheet: Covalent Compounds

H	O	H_2O
H	N	NH_3
Cl	C	CH_4
Cl	P	PCl_3
C	Cl	CCl_4
H	Cl	HCl
	H	PH_3

To Bond, or Not to Bond

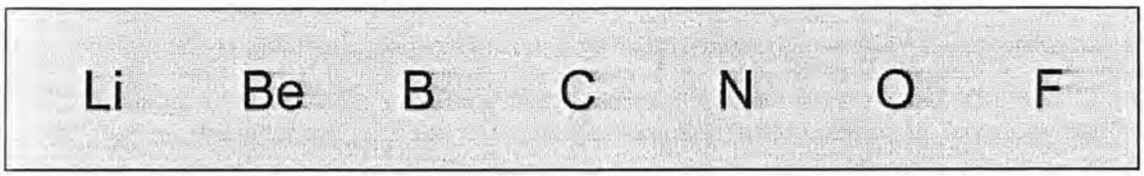
Student Reference Sheet: Student Cutout

Lithium fluoride, LiF	Methane, CH_4	Diatomic oxygen, O_2
Carbon dioxide, CO_2	Aluminum phosphide, AlP	Sodium chloride, NaCl

Part 2: Electron Dot Formulas for Covalent Compounds

Electron Dot Formula Basics

Electron dot formulas are visual representations of the outermost valence electrons in an atom.The number of valence electrons of atoms follows a very predictable pattern. The valence electrons found in the main group elements, or the representative elements, increase as you move from left to right on the Periodic Table. Each individual atom will have a specific number of valence electrons that can be represented by electron dot formulas. Easy, right?



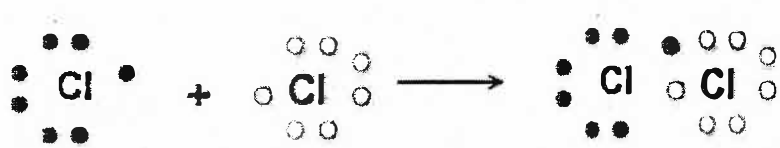
Electron Dot Formulas for Covalent Compounds

Covalent compounds are formed from a combination of two or more nonmetals, or of a metalloid and a nonmetal. The compounds formed are known as molecules and are neutral, meaning they do not have a charge. Therefore, covalent compounds are not created by balancing charges, but by sharing the electrons that bond them together. The electrons are shared in pairs. There are a few rules that must be followed when pairing electrons in covalent bonds. Remember that atoms "like" to live in a stable state with a full octet of electrons, with hydrogen being the exception as it is stable with only two electrons. With this said, atoms in covalent compounds will combine so that each atom has a full octet of electrons in its electron shell. Atoms will achieve a full octet in covalent bonds by sharing electrons.

Molecular chlorine (Cl2) is a diatomic molecule. It consists of two chlorine atoms sharing their electrons, forming a covalent bond. The electron dot formula of each individual chlorine atom has seven valence electrons. When the chlorine atoms combine, each atom shares the 7th electron with the other atom, giving each chlorine atom within the molecule the required eight valence electrons.

The pair of shared electrons between the chlorine atoms forms a bond, represented by a straight line. These electrons are known as bonding pairs of electrons. For molecules with single bonds, the line represents the bond formed by the electron pair. The electrons that do not form the bond are called "lone pairs" of electrons. The following is an example of how these two atoms bond. Notice that the bonding pairs of electrons between the chlorine atoms is represented on the right by a single straight line, representing a single bond. This is the correct structural formula, or a chemical formula that shows the arrangement of atoms in a molecule.

Example:



Bond between an electron pair, shown in electron dot diagrams

Atoms may also have double or triple bonds between atoms, depending on how many bonding pairs are required.

Procedure for Writing Electron Dot Formula on Cards:

1. Remove cards and use a dry erase marker to draw dots on each of the element symbols.
2. Arrange the elements to create a compound.
3. Fill in the chart to draw the dot structure and write the formula.
4. Create a minimum of five different compounds.
5. Return the cards to the bag when finished, then answer the following questions.

Element 1	Element 2	Sot Structure	Formula

A. What are covalent compounds, and how are they formed?

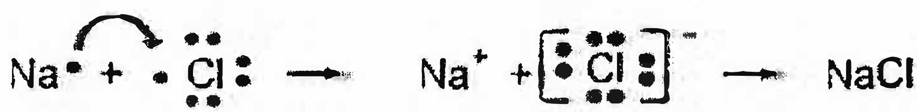
B. What is meant by "a full octet," and why do atoms prefer to have this?

C. When atoms combine covalently to create bonds, how is the shared pair of electrons represented in the electron dot formula? In other words, what is placed between the atoms of a molecule to represent a shared pair of electrons?

Part 3: Electron Dot Formulas for Ionic Compounds

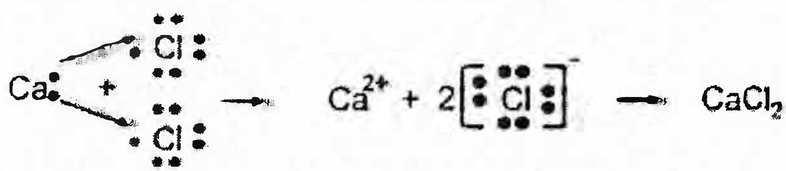
The electron dot formulas for ionic compounds follow slightly different rules. As you know, ions have a charge. Ionic compounds are formed when positively-charged atoms, called cations, bond with negatively-charged atoms, or anions, forming a neutral salt. The electron dot formula will show how these atoms bond. Look at the following examples.

A sodium cation (Na+), with a positive 1 (1+) charge, and a negative chloride anion (Cl-), with a negative 1 (1-) charge, will combine in a 1:1 ratio to form a neutral sodium chloride salt crystal.



Electron dot diagram formulas for ionic compounds example

A positively-charged calcium (Ca^{2+}) cation will bond with two negatively-charged chloride (Cl-) anions to form neutral calcium chloride ($CaCl_2$) salt. As the calcium ion carries a charge of positive 2 (2+), it will take two chloride ions to balance this charge. Therefore, these two elements will combine in a 1:2 ratio to form a neutral calcium chloride salt crystal.



Electron dot diagram formulas for ionic compounds example

1. Obtain a bag labeled "Ionic Compounds." Inside are a variety of chemical symbols for several representative elements, including their charges.
2. Arrange the elements to create a compound.
3. Fill in the chart to draw the dot structure and write the formula.

Element 1	Element 2	Dot Structure	Formula
Na^+	Cl^-		NaCl

4. Create a minimum of five different compounds.
5. Return the cards to the bag when finished, then answer the following questions.
    a. Show the electron dot formulas to illustrate the bonding process for the following ionic compounds:
        i. MgF_2 (magnesium fluoride)
        ii. K_2O (potassium oxide)
    b. Describe how the electron dot formulas of ionic compounds illustrate that electrons are either gained or lost during the bonding process.
    c. Why is it important to include a charge when creating electron dot formulas for ions?

Module 2, Unit 2: Chemical Reactions
Lesson 2: Molar Mass

HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Goals: What is a mole? What is molar mass? In this lesson, students will be able to explain, describe and calculate the mole and molar mass in their activity report. This lesson is the key to understand the next lesson, balancing equations.

Activity: Molar Mass and the Mole
Materials:
- Triple beam balance or electronic balance
- Element bottles:
  - Weight each empty bottle and write the mass of the empty bottle on the bottle.
  - Aluminum bottles: place 26.98 g of Al in a bottle and label it Aluminum
  - Carbon bottles: place 12.00 g of carbon in a bottle and label it Carbon
  - Sulfur bottles: place 32.00 g of sulfur in a bottle and label it Sulfur

Note:
- Teachers do not have to use these 3 elements. They are chosen because they are safe, inexpensive, and most high school chemistry labs have them.
- Teachers can use any other safe elements such as iron, copper, sand (Silicon),water, calcium, magnesium for substitute.
- Please **do not** use highly active elements such as sodium, lithium, potassium, halogen group (Flourine, Chlorine, Bromine, etc.).

Molar Mass and The Mole

1

Math Review

Convert 425 meters to miles

(1 km = 1000 m; 1 mile = 1.67 km)

2

Math Review

Convert 425 meters to miles

$$\frac{425\ m}{1} \times \frac{1\ Km}{1000\ m} \times \frac{1\ mile}{1.67\ Km} = 0.25\ miles$$

Introduction to the Mole

- You will measure a mole of several elements.
- Find the mass of each element: Find the mass of the element by weighing the entire bottle then subtract the mass of the empty bottle to get the mass of the element inside the bottle.
- Using your periodic table record the symbol, atomic number, and atomic mass for each element.
- Do you notice any patterns about the masses of the mole sample?
- How do you think scientist counted out a mole of atoms of each element?

Introduction to the Mole

Sample	Mass of sample and container (g)	Mass of container (g)	Mass of sample (g)	Symbol of Sample	Atomic Number of Sample	Atomic Mass of Sample
Aluminum						
Carbon						
Sulfur						

Atomic Mass (AMU)

- The mass of a single atom.
- We cannot measure something this small.
- We use molar mass instead.
- Example:
  - The atomic mass of lead is 207.2 amu
  - If we weigh out 207.2 g of lead, we have the molar mass of lead

The Mole

- The "mole" is a unit of measurement used to count the number of particles found within a substance.
- This is similar to using:
  - Dozen (12)
  - Pair (2)
  - Ream (500)
  - Gross (144)

7

The Mole

- A "mole" equals 602,000,000,000,000,000,000,000 particles or 6.02×10^{23} particles.
- It was found using carbon-12:
  - 12.01 g of carbon has 6.02×10^{23} atoms of carbon.
  - Known as the Avogadro number

8

Examples

Ex 1: How many moles of Mg are in 1.25×10^{23} atoms?
Atoms --> moles

$$1.25 \times 10^{23} \text{ atoms} \times \frac{1 \text{ mole}}{6.02\times10^{23} \text{ atoms}} = 0.208 \text{ mol}$$

Ex 2: How many atoms of C are in 2.0 moles?

Moles --> atoms

$$2 \text{ mol} \times \frac{6.02\times10^{23} \text{ atoms}}{1 \text{ mol}} = 1.2 \times 10^{24} \text{ atoms}$$

9

Molar Mass

- The mass in gram of 1 mole of substance.
- To find the molar mass, just look on the periodic table at atomic mass.

10

Molar Mass

Mass (g) ⇔ moles (mol)

If grams is given and you want to get moles:

$$\_\_\_\text{grams} \times \frac{1\text{ mol}}{\text{molar mass (g)}} = \_\_\_\text{ mol}$$

If moles is given and you want to get grams

$$\_\_\_\text{mol} \times \frac{\text{molar mass (g)}}{1\text{ mol}} = \_\_\_\text{ grams}$$

11

Molar Mass

Ex. 1: How many moles are in 92.2 grams of Fe?

g--> mole

molar mass= 55.85g

$$92.2\text{ g }Fe_2O_3 \times \frac{1\text{ mol Fe}}{55.85\text{ g Fe}} = 1.65\text{ mol Fe}$$

12

Molar Mass

Ex. 2: What is the mass of 9.45 mol of Al?

Mol --> gram

$$9.45 \text{ mol Al} \times \frac{26.98 \text{g Al}}{1 \text{ mol Al}} = 255 \text{ g Al}$$

Types of Chemical Reactions

- When you know the patterns that reactions follow, you can predict the products that you will create from almost any reactants.
- There are 6 different types of chemical reactions:

1. **Neutralization**
   - Mixture of an acid and a base, creating water and an ionic salt.

2. Synthesis
- This is the simplest reaction.
- 2 reactants form 1 product.
  - Ex. Element 1 + Element 2 → Compound
- Could be metal + non-metal, or non-metals reacting.
- Examples:

$Mg_{(s)} + O_{2\,(g)} \rightarrow MgO_{(s)}$
$H_{2\,(g)} + N_{2\,(g)} \rightarrow NH_{3\,(g)}$
$Na_{(s)} + S_{8\,(s)} \rightarrow Na_2S_{(s)}$

3. Decomposition
- This is like a reversed synthesis reaction.
- 1 reactant breaks down into 2 products.
  - Ex. Compound → Element 1 + Element 2
- Look for more complicated compounds breaking down into simpler substances.
- Examples:

$H_2O_{(l)} \rightarrow H_{2\,(g)} + O_{2\,(g)}$
$CaCO_{3\,(s)} \rightarrow CO_{2\,(g)} + Ca_{(s)} + O_{2\,(g)}$
$Ca_2F_{(s)} \rightarrow Ca_{(s)} + F_{2\,(g)}$

4. **Combustion**
- The combustion of hydrocarbons (a compound containing carbon and hydrogen) with oxygen occurs when fossil fuels are burned.
- $C_xH_y + O_2 \rightarrow CO_2 + H_2O$ + heat
- Example:

$C_8H_{18\,(g)} + O_{2\,(g)} \rightarrow H_2O_{(g)} + CO_{2\,(g)}$

- The combustion of hydrocarbons is often responsible for the production of many harmful substances like:
  - Carbon monoxide
  - Sulfur dioxides
  - Nitrogen oxides

5. **Single Displacement**
- One element reacts with an ionic compound.
- The metal of the compound changes place with the single element metal.
- AB + C → CB + A
- Examples:

$AgNO_{3\,(s)} + Ca_{(s)} \rightarrow Ca(NO_3)_{2\,(s)} + Ag_{(s)}$
$Li_2O_{(aq)} + Cl_{2\,(g)} \rightarrow LiCl_{2\,(g)} + O_{2\,(g)}$

6. **Double Displacement**
- Two ionic compounds react and switch ions of the same charge.
- The metals, or non-metals, of the compounds changes places.
- AB + CD → CB + AD
- Examples:

$CaF_{2\,(aq)} + CuO_{(aq)} \rightarrow CaO_{(aq)} + CuF_{2\,(s)}$
$Al_2(CO_3)_{3\,(aq)} + MgSO_{4\,(aq)} \rightarrow MgCO_{3\,(aq)} + Al_2(SO_4)_{3\,(aq)}$

Chemical Reactions

Name ______________________

1. Watch the video and then complete the chart.

Type of Reaction	Definition	★ Equation
Synthesis		___ + ___ → ___
Decomposition		___ → ___ + ___
Single Replacement		___ + ___ → ___ + ___
Double Replacement		___ + ___ → ___ + ___

Colors: A = Red, B = Blue, C = Green, D = Yellow

2. Use colored pencils to circle the common atoms or compounds in each equation to help you determine the type of reaction it illustrates. Use the code below to classify each reaction.

S = Synthesis D = Decomposition SR = Single Replacement DR = Double Replacement

____ $P + O_2 \rightarrow P_4O_{10}$	____ $Mg + O_2 \rightarrow MgO$
____ $HgO \rightarrow Hg + O_2$	____ $Al_2O_3 \rightarrow Al + O_2$
____ $Cl_2 + NaBr \rightarrow NaCl + Br_2$	____ $H_2 + N_2 \rightarrow NH_3$
____ $Na + Br_2 \rightarrow NaBr$	____ $CuCl_2 + H_2S \rightarrow CuS + HCl$
____ $HgO + Cl_2 \rightarrow HgCl + O_2$	____ $C + H_2 \rightarrow CH_4$
____ $KClO_3 \rightarrow KCl + O_2$	____ $S_8 + F_2 \rightarrow SF_6$
____ $BaCl_2 + Na_2SO_4 \rightarrow NaCl + BaSO_4$	

Balancing Chemical Equations

Word Equations

REACTANTS ⟶ **PRODUCTS**

(left side) (right side)

- A way of representing a chemical reaction.
- Reactants are the substances that are present initially.
- Products are the substances that are produced.
- An arrow is used to indicate the direction of the chemical reaction.
- A plus sign is used to separate each reactant and each product.

Example:

hydrogen + oxygen ⟶ water

Skeleton Equations

A word equation shows the reactants and products of a reaction, but it does not provide information about the chemical composition of the substances. Replacing the words with chemical formulas produces a skeleton equation.

Example:

$$H_2 + O_2 \longrightarrow H_2O$$

The **state** of any substance in a chemical equation can be described using one of the following symbols placed after the formula of the substance:

State	Symbol
Solid	(s)
Liquid	(l)
Gas	(g)
Aqueous (dissolved in water)	(aq)

Example:

Law of Conservation of Mass:

In any given chemical reaction,

$$H_{2(g)} + O_{2(g)} \rightarrow H_2O_{(l)}$$

Balanced Chemical Equations

Although the skeleton equation shows the composition of each substance, it does not show the number of reactants or products. A balanced chemical equation demonstrates the law of conservation of mass, which requires the same number of atoms of each element on both sides of the chemical equation.

Example:

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$$

How to Balance a Chemical Equation

Example 1 Write the balanced chemical equation for the reaction between aluminum and oxygen gas to produce aluminum oxide.

Step 1: Write the word equation (if necessary)

Aluminum + Oxygen → Aluminum oxide

Step 2: Write a skeleton equation

$$Al_{(s)} + O_{2(g)} \rightarrow Al_2O_{3(s)}$$

Step 3: *a) Draw symbols below each formula to represent the exact number of atoms that are present.*

b) If the number of atoms of one element is not equal on both sides, add another entire reactant or product until the numbers of atoms are equal on both sides. (Repeat Step for all atoms)

$$Al_{(s)} \quad + \quad O_{2(g)} \quad \rightarrow \quad Al_2O_{3(s)}$$

Symbols

$$Al_{(s)} \quad + \quad O_{2(g)} \quad \rightarrow \quad Al_2O_{3(s)}$$

Element Count

*Step 4: Count how many of each reactant and product you have used to balance the atoms and put the appropriate **coefficients** in front of the formulas to balance the number of atoms. Make sure to check when finished.*

$$\_\_ Al_{(s)} + \_\_ O_{2(g)} \rightarrow \_\_ Al_2O_{3(s)}$$

Example 2

Aluminum oxide + Calcium → Calcium oxide + Aluminum

Helpful Tips

What do the numbers mean?	
Coefficient	$3H_2O$
	Subscript

1. Remember, when trying to balance equations, you can only change the value of the coefficient in front of the compound or element, **not** the subscripts.

2. Balance the element, other than hydrogen and oxyge *of atoms* in any reactant or product.

3. Balance other elements, other than hydrogen and oxygen.

4. Balance oxygen or hydrogen, whichever one is present in the combined state (with something else i.e. H_2S). **Leave until last** whichever one is present in the uncombined state (by itself i.e. H_2).

5. Check that the equation is balanced by counting the number of atoms of each element on each side of the equation.

6. When the equation is balanced, the coefficients should be in their **lowest** terms. For example, the balanced equation for the reaction between hydrogen and oxygen is:

Correct $\underline{2}H_2 + O_2 \rightarrow \underline{2}H_20$

NOT Correct! $\underline{4}H_2 + \underline{2}O_2 \rightarrow \underline{4}H_2O$

Balancing Chemical Equations

Balance the equations below:

1) ____ N_2 + ____ H_2 → ____ NH_3

2) ____ $KClO_3$ → ____ KCl + ____ O_2

3) ____ $NaCl$ + ____ F_2 → ____ NaF + ____ Cl_2

4) ____ H_2 + ____ O_2 → ____ H_2O

5) ____ $Pb(OH)_2$ + ____ HCl → ____ H_2O + ____ $PbCl_2$

6) ____ $AlBr_3$ + ____ K_2SO_4 → ____ KBr + ____ $Al_2(SO_4)_3$

7) ____ CH_4 + ____ O_2 → ____ CO_2 + ____ H_2O

8) ____ C_3H_8 + ____ O_2 → ____ CO_2 + ____ H_2O

9) ____ C_8H_{18} + ____ O_2 → ____ CO_2 + ____ H_2O

10) ____ $FeCl_3$ + ____ $NaOH$ → ____ $Fe(OH)_3$ + ____ $NaCl$

11) ____ P + ____ O_2 → ____ P_2O_5

12) ____ Na + ____ H_2O → ____ $NaOH$ + ____ H_2

13) ____ Ag_2O → ____ Ag + ____ O_2

14) ____ S_8 + ____ O_2 → ____ SO_3

15) ____ CO_2 + ____ H_2O → ____ $C_6H_{12}O_6$ + ____ O_2

16) ____ K + ____ $MgBr$ → ____ KBr + ____ Mg

17) ____ HCl + ____ $CaCO_3$ → ____ $CaCl_2$ + ____ H_2O + ____ CO_2

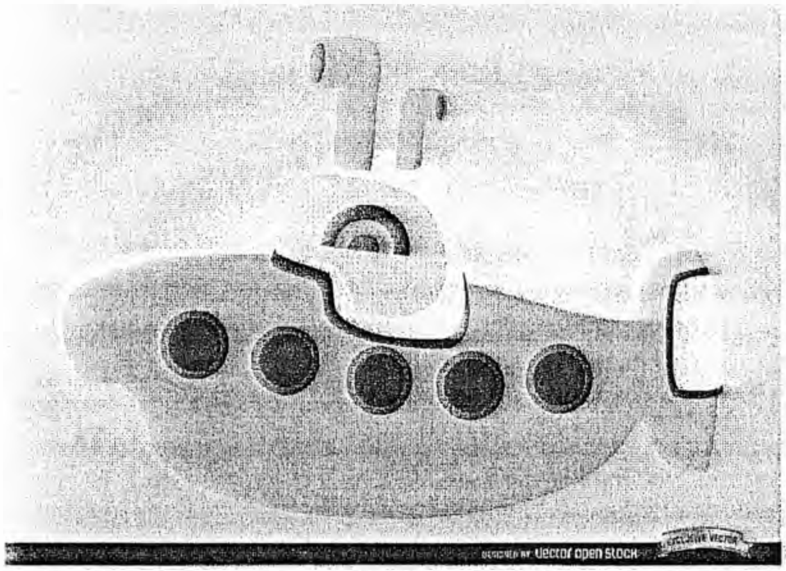
18) ____ HNO_3 + ____ $NaHCO_3$ → ____ $NaNO_3$ + ____ H_2O + ____ CO_2

19) ____ H_2O + ____ O_2 → ____ H_2O_2

20) ____ $NaBr$ + ____ CaF_2 → ____ NaF + ____ $CaBr_2$

21) ____ H_2SO_4 + ____ $NaNO_2$ → ____ HNO_2 + ____ Na_2SO_4

Module 2, Unit 2: Chemical Reactions
Lesson 4: Yellow Submarine



HS-PS1-2: Construct and revise and explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic, and knowledge of the patterns of chemical properties.

Goals: How do the US Navy generate Oxygen and remove CO_2 in their nuclear submarines? In this lesson, students will be able to use electrolysis of water to explain the process of producing oxygen in a nuclear submarine. Students will also be able to use similar process to explain and determine how CO_2 is being removed in the submarine.

Part A: Make LO_2VE, not war: Electrolysis of water

1) Procedure:
   a) Materials:
      i) 1 600 ml beaker
      ii) 1 9-V battery
      iii) 400 ml of water
      iv) 2 test tubes
      v) Table salt (a pinch)

   b) Fill the beaker with 400 ml of water
   c) Mix the pinch of salt in the water
   d) Fill the 2 test tubes with water from the beaker and turn it upside down in such a way that the water remain in the tubes.

e) Put the 9-v battery in the beaker, with the 2 electrodes (positive and negative) pointed to the top of the beaker.
f) You will see bubbles coming out of the electrodes. Put the 2 test tubes over the electrodes to trap the bubbles.
g) Draw a diagram of your set up.
h) **Observation:** what do you observe about the volume of the gases collected in each tube?

2) The equation:
   a) Write a balanced equation for the electrolysis of water.
   b) What kind of reaction is electrolysis of water?
   c) Which tube contain Oxygen? Which tube contain Hydrogen? Explain.
   d) What can you do to confirm your explanation?

3) Stoichiometry:
   a) A US nuclear submarine has a crew of 150 people (on average). How much water is needed to produce enough Oxygen for the crew in 1 day? (a person consumes 550 L of Oxygen a day)

<u>Part B:</u> CO_2 Scrubber

1) **Theory:** on average, a person produced about 4 kg of CO_2 a day (assuming the person not engaging in vigorous exercise all day). The US Navy used a "CO_2 scrubber" called MEA: MonoEthanolAmine to absorb the CO_2 in the submarine. The CO_2 chemically reacted with the Amine to form a new substance. This substance is later heated to release the CO_2, and MEA can be reuse again.

2) The equation: Write a balanced chemical equation for the scrubber.

3) What kind of reaction is the scrubber?

4) How much scrubber is needed per day in a nuclear submarine?

<u>Part C:</u> Synthesis of macromolecules - MonoethanolAmine: $NH_2CH_2CH_2OH$

1) Monomers and Polymers:

- Monomers are like Lego. They are the building blocks for more complex polymers in living things.
- Example: MonoethanolAmine is a perfect example of a polymer. It has 3 monomers: the Amine (NH_2), the alcohol (OH), and the ethane (CH_2CH_2). These monomers are the building blocks for monoethanolAmine.
- Monomer cards: Write each monomer on a 3x5 index card. Rearrange the card to make new macromolecules.
- Write a possible synthesis reaction for MonoethanolAmine.

- What is the molecular formula for nucleic acid?
    - Teacher note: teacher can provide the molecular formula of nucleic acid for students, or teachers can have students research and find out the molecular formula of nucleic acid.
- Identify the monomers in nucleic acid

NH_2-	-OH
-CH_2-	-CH_2-
NH_2-	-OH
-CH_2-	-CH_2-
NH_2-	-OH

$-CH_2-$	$-CH_2-$
NH_2-	$-OH$
$-CH_2-$	$-CH_2-$
NH_2-	$-OH$
$-CH_2-$	$-CH_2-$

3D Balancing of Chemical Equations

- Demonstrate through either video or a series of images these types of reactions; Neutralization, Synthesis, Decomposition, Combustion, Single Displacement, Double Displacement.
  - Law of Conservation of Mass must be described.

Questions

1. What is the Law of Conservation of Mass, and how does it relate to chemical reactions?
2. Explain how the Law of Conservation of Mass was demonstrated in you model.
3. Why the conservation of mass is important to Earth's processes and Life on Earth.