Chemistry

Unit 3: Atoms, Elements, and Molecules

Workbook 3

Round 2

Name: _____ Period: _____

Guiding Question:

Do Now:

Important Definitions and Equations:

Notes:

_____ is a convenient way to write numbers that have lots of zeros, either because they are very large or very small.
This is helpful when looking at atoms because a very small amount of substance contains an enormously large number of atoms.

However, keeping track of all those atoms, even using scientific notation is cumbersome so chemists use a unit called the mole.
The mole is simply a counting unit. Just as one dozen is always equal to 12 objects, regardless of what they are, 1 mole is always equal to 6.02×10^{23} objects.

1 mole =
=
=
=

The mass of 1 mole of a substance is called the molar mass.
The molar mass of each element can be found on the periodic table

6.02×10^{23} was picked because it is the number of atoms needed so that the average atomic mass of one atom in amu is the same number as the mass in grams found in a mole.
For example the molar mass of bromine (79.9 g/mol) is the same number as the average atomic mass of bromine (79.9 amu).

Response:

14 Holey Moley
The Mole

The Mole

Video on **moles:**

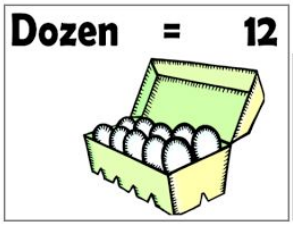
1. What is a "mole" used for in chemistry?

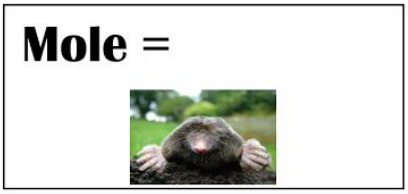
2. What is **Avogadro's number?** _____

3. What is another name for Avogadro's number? _____

4. Why are moles useful in science? What's the purpose of a mole?

5. How is a "mole" similar to a "dozen"?





Questions

1. How many candies are in a mole of candies?
2. How many molecules are in a mole of water, H_2O?
3. How many atoms are there in a mole of sodium?
4. Why do scientists use moles?

5. One mole of helium atoms has a mass of 4.00 grams. How many ***atoms*** would be in 12.00 grams of helium?

6. How do you know?

7. One mole of nitrogen atoms has a mass of 14.01grams. How many atoms would be in 28.02 grams of nitrogen?

8. How do you know?

9. You have 2 moles of baseballs. How many baseballs is this?

10. How do you know?

11. One iron nail has a mass of roughly 2.5g. If one mole of iron atoms has a mass of 55.85g, how many iron nails would it take to make one mole of iron? Explain your reasoning or show work.

Guiding Question:

Do Now:

Important Definitions and Equations:

Notes:

You can figure out the mass of 1 mole of any element or compound by using the periodic table.

•For a compound, you must sum the molar mass of all the atoms in the molecule

Example:

A mole of atoms or molecules of a solid or liquid is usually an amount you can hold in your hand.

A mole of any gas, if it is at standard temperature and pressure, always has a volume of 22.4 L

Just like 1 dozen has 12 eggs in it, there is 6.022×10^{23} particles in one mole of ANY substance.

Because 1 mole represents a quantity and never a specific mass, the mass of one mole of any substance is equal to its average atomic mass found on the periodic table.

- This is called the molar mass.

Response:

15 Sums Up
Molar Mass

Molar Mass

So, now we know that moles come in handy when we are talking about mass. Who wants to talk about the mass of one individual thing when you can talk about the mass of 602,000,000,000,000,000,000,000 of them?! We saw that a mole of hydrogen atoms had a mass of 1.01 g. **The mass of a mole of something is called the *molar mass* (see the word "mole" in "molar"?).**

Let's make up a word for a moment = "dozenar mass". This term would refer to the mass of a dozen of something. A dozen golf balls would have a mass of 62 grams, meaning the dozenar mass of golf balls is 62 g/dozen. A dozen cotton balls, however, would have a mass of 10 grams, meaning the dozenar mass of cotton is 10 g/dozen. See, we can use *molar* mass to talk about anything—hot dogs, H_2O compounds, lone gold atoms, whatever, as we are just talking about the *mass* of 6.02×10^{23} of those things.

7. What is **molar mass** (in your own words)?

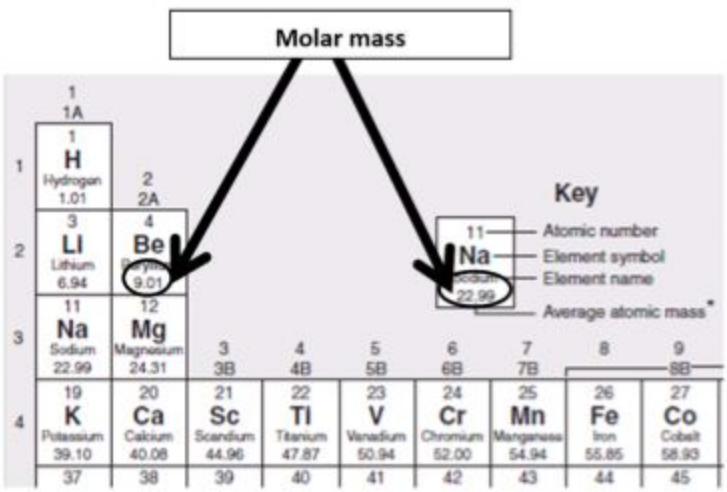
8. How is it possible that a mole of hydrogen has a different molar mass than a mole of carbon atoms – even though both moles have 6.02×10^{23} atoms?

9. Which would have a larger mass: a mole of baseballs or one bowling ball? Why do you think this?

How do we calculate the molar mass??

One of the *most important* skills in chemistry is to be able to calculate the molar mass of an element or compound. First, let's take a look at the periodic table (YAYYY!!!! WE GET TO USE PERIODIC TABLES AGAIN!!! I know it is quiet reading time, but I understand if you cheer with excitement at this point). The **molar mass** of an element is located at the bottom of the periodic table. For example, Hydrogen has a **molar mass** of 1.01 gram/mol (pronounced "grams per mole"). This means that 1 mole of hydrogen atoms (6.02×10^{23} Hydrogen atoms) has a mass of 1.01 grams. The label for molar mass is "*grams per mole"* and is written g/mol. This label helps us remember that the molar mass is the # of grams in each mole of the substance.

Finding the molar mass of individual elements:



10. What is the molar mass of magnesium (include the units)?

11. What is the molar mass of chlorine atoms (include the units)?

12. What is the molar mass of lithium atoms (include the units)?

Ok, that was pretty easy. But how do we calculate the molar mass of a compound?

We need to know how to use the molar masses of individual elements to determine the molar masses of whole compounds. We calculate the molar mass *of a compound* by adding the masses *of the atoms that make it up*. For example, the molar mass of H_2O would be the molar mass of 2 hydrogen atoms and 1 oxygen atom added together. Each hydrogen atom has a molar mass of 1.01 g/mol. Oxygen has a molar mass of 16.00 g/mol.

<u>EXAMPLE:</u> Find the molar mass of 1 mole of H_2O

STEP 1: Use the periodic table to find the molar mass of each element in the compound (you may round)

Molar mass of Hydrogen = 1.01 g/mol

Molar mass of Oxygen = 16.0 g/mol

STEP 2: Use the coefficients to figure out how many of each atom is in 1 molecule. Then multiply the molar mass of each element by how many of each element you have

H_2O = has 2 hydrogen atoms and 1 oxygen atoms

For the 2 hydrogen atoms…

2 x 1.01 g/mol H = ***2.02 g/mol***

For the 1 oxygen atom…

1 x 16.00 g/mol O = ***16.00 g/mol***

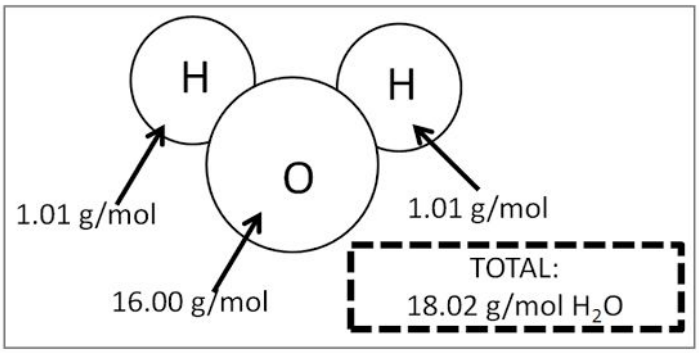
STEP 3: Add together the masses from each element to get the molar mass of the compound

Adding these together to make H_2O….

2.02 g/mol + 16.00 g/mol = ***18.02 g/mol H_2O***

Molar mass of H_2O = 18.02 g/mol

In picture form:



This, of course, means that 6.02 x 10^{23} little molecules of water have a mass of 18.02 grams.

13. Describe in words how you calculate the molar mass of a **<u>compound</u>**?

14. What is the molar mass of $CaCl_2$?

<u>STEP 1</u>: Count the atoms of each element in $CaCl_2$

A) There are _____ Ca atoms

B) There are _____ Cl atoms

<u>STEP 2:</u> Find the molar mass of each element from the periodic table

A) The molar mass of Ca is _____ g/mol

B) The molar mass of Cl is _____ g/mol

CHECK!! WHY is the label for molar mass "g/mol" _____

Multiply the molar mass of each element by how many there are in the compound below:
(Need help?? Step 1 (A) x Step 2 (A) = …)

<u>STEP 3:</u> Add together the masses from each element to find the molar mass

FINAL ANSWER (include units) = _____

Practice

15. What is the molar mass of C_2HF_3? (Show your work below. Include units.)

16. What is the molar mass of $Mg(OH)_2$? (Show your work below. Include units)

17. What is the molar mass of $Na(PO_4)_2$? (Show your work below. Include units)

18. What is the molar mass of $(NH_4)_2O$? (Show your work below. Include units)

Guiding Question:

Do Now:

Important Definitions and Equations:	**Notes:**

Response:

17 Mountains into Molehills

Gram and mole conversions

For the next two weeks we are going to be working on stoichiometry, which pretty much means math in chemistry. The big objective for the next two weeks is "WWBAT calculate the grams of one substance when given the grams of another substance." This objective is the hardest—but the best!—objective in chemistry. One of these problems looks like this:

If you have 20 grams of water (H_2O). How many grams of O_2 could you make, according to the following reaction?

$$2H_2O \rightarrow 2H_2 + O_2$$

To solve this problem, we have to break it down into three steps. Today you will practice step one, first we must be able to convert between moles and grams. I am completely confident that if you work hard today you will master this! Don't fear, CheMasters – you will master this objective!

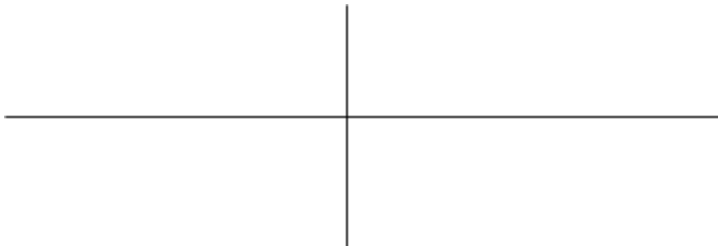
So let's try this…

STEP 1: Plan the attack - set up conversion map. This tells you what units and substance you start with and what you want to end with. Eventually, you will add more to this to indicate how you will change something multiple times. For now, a conversion map looks like this:

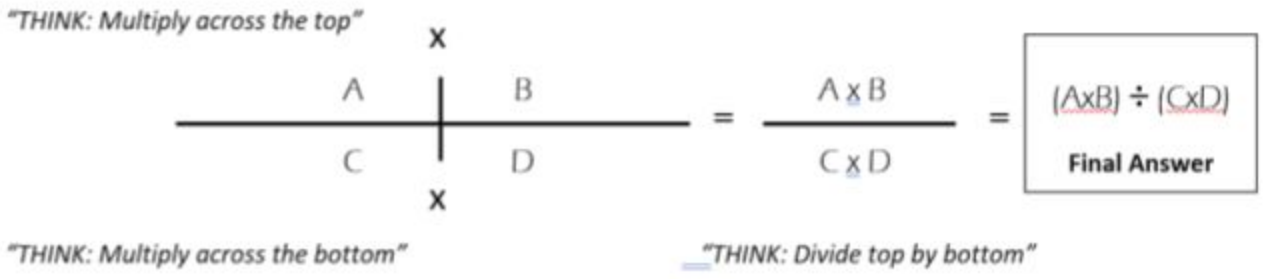
$$20g\ H_2O \rightarrow g\ O_2$$

STEP 2: Prepare your battlefield – set up a chart. Set up something called a "t-chart" or "railroad tracks" like you learned in math. A t-chart is tool that will help us decide when to divide and when to multiply in a stoichiometry problem.

A t-chart looks like this:



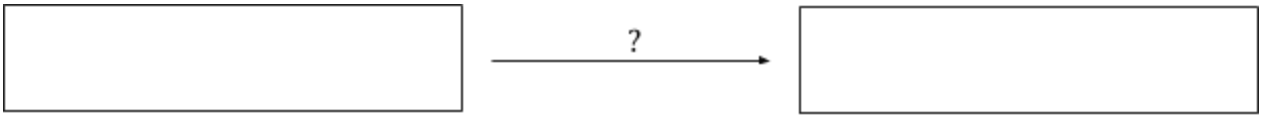
STEP 3: Solve - Here is how you use a t-chart: The letters (A-D) are there just to show you when you multiply and divide. In a t-chart, you multiply across the top and bottom to get a simplified fraction. Then, you divide the fraction to get your final answer



Let's see if we can set up a t-chart with a problem that we already know how to answer!

PROBLEM #1 – There are 25 dozen pencils in the pencil case. How many pencils do you have in total?

Roadmap to success: "THINK: What can I use to move from dozen to individual pencils? What is your conversion factor?"

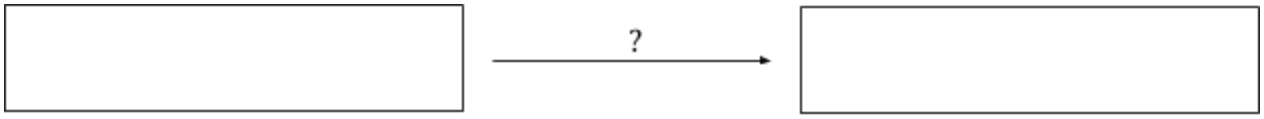


Do the DISCO! *"THINK: The units you want to cancel out must go diagonal from each other."*

Final Answer (include units and substance)

PROBLEM #2 – You have 42 inches of string, but you need to know how many feet of string you have. (Remember, you know there are 12 inches in 1 foot)

Roadmap to success: "THINK: What can I use to move from inches to feet? What is your conversion factor?"

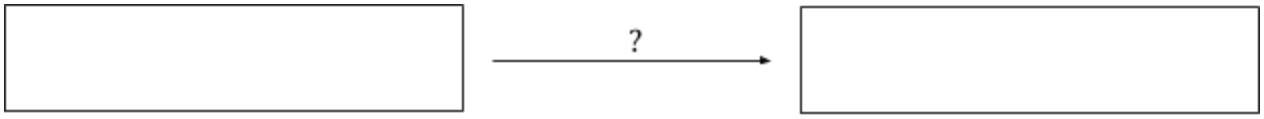


Do the DISCO! *"THINK: The units you want to cancel out must go diagonal from each other."*

Final Answer (include units and substance)

PROBLEM #3 – A carpenter measures a window to have a length of 655 centimeters. How many meters is the window? (There are 100 centimeters in 1 meter)

Roadmap to success: "THINK: What can I use to move from centimeters to meters? What is your conversion factor?"



Do the DISCO! *"THINK: The units you want to cancel out must go diagonal from each other."*

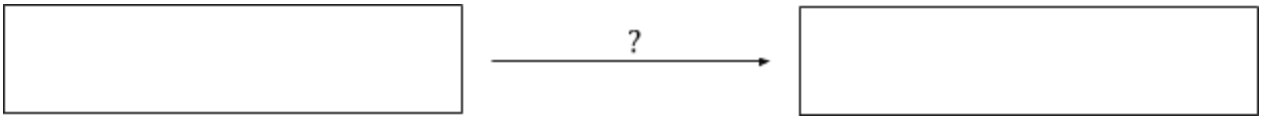
Final Answer (include units and substance)

Workbook 3.3 Date:

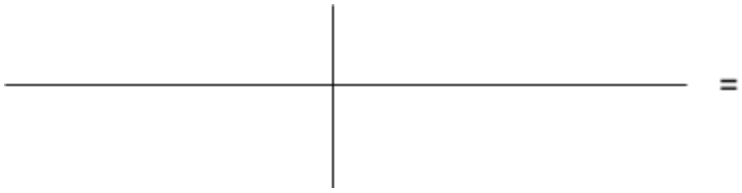
Now with a chemistry problem…

PROBLEM #4 – You have 20 grams of water and you want to know how many moles of water that is.

STEP 1: Roadmap to success: "THINK: What can I use to move from grams to moles? What is your conversion factor?"



STEP 2: The first step is to set up our t-chart. Remember to write the given information in the upper left hand box. DO THE DISCO!!!! "THINK: The units you want to cancel out must go diagonal from each other"



But what do we do now? Where is our conversion factor?

Calm down! The conversion factor comes from the molar mass which we calculate from the periodic table. This is what we did during yesterday's lesson and today's catalyst.

Check yourself: Why does it make sense that we can use molar mass to convert from grams to moles of a substance? HINT: think about the units!!

_____

_____

STEP 2: Calculate the molar mass of water:

The molar mass of water is (include your units!):

The molar mass is our conversion factor; this is what goes in the *second box* on our t-chart. This is so that the units *cancel.*

STEP 3: Fill in the rest of the t-chart and solve. Cross off units as you go through to get the units of your final answer.

Final Answer (include units and substance)

PAUSE AND THINK: Recap the "swing" from moles to grams in words. What did we just do? How did we do it?

_____

_____

_____

_____

Try one on your own now:

PROBLEM #4 – Let's say that you have 5.4 grams of NaF and you want to know how many moles of NaF that is.

STEP 1: Make a plan and set up your t-chart

Roadmap to success: "THINK: What can I use to move from grams to moles? What is your conversion factor?"

	?	
	→	

STEP 2: *DO THE DISCO!* Remember to write the given information in the upper left hand box. "THINK: The units you want to cancel out must go diagonal from each other"

STEP 3: Calculate the molar mass of NaF:

The molar mass of NaF is (include your units!) = _____

Check yo'self!! WHY did you need to do step 3? What does finding the molar mass of NaF help you do?

_____

_____

STEP 4: Fill in the rest of the t-chart and solve: Cross off units as you go through to get the units of your final answer.

Final Answer (include units and substance)

Workbook 3.3 Date:

REVERSE IT: Going from moles to grams

PROBLEM #5 – How many grams are in 0.25 moles of BeI_2?

STEP 1: Make a plan and set up your t-chart

Roadmap to success: "THINK: What can I use to move from moles to grams? What is your conversion factor?"

	?	
	→	

STEP 2: *DO THE DISCO!* Remember to write the given information in the upper left hand box. "THINK: The units you want to cancel out must go diagonal from each other"

		=

STEP 3: Calculate the molar mass of BeI_2:

The molar mass of BeI_2 is (include your units!) = _____

Check yo'self!! WHY did you need to do step 3? What does finding the molar mass of BeI2 help you do?

_____

_____

STEP 4: Fill in the rest of the t-chart and solve: Cross off units as you go through to get the units of your final answer.

		=	

Final Answer (include units and substance)

Whew – you did it! Make sure you understand the KEY POINTS below!

Re-Cap: Overview of conversions between grams and moles

Molar mass (g/mol)

mass (g) **moles (mol)**

MOST IMPORTANT thing is to check what units you WANT to end up with and do the disco!!

$$\frac{\text{Given Info} \mid \text{Units we } \mathbf{Want}}{\text{Units to Cancel}} =$$

Workbook 3.3 Date:

Practice Time – grams to moles problems

1. How many moles are in 20 grams of H_3PO_4?

Final Answer (include units and substance)

2. You have 115 grams of $NaHCO_3$, how many moles of $NaHCO_3$ do you have?

Final Answer (include units and substance)

3. How many moles are in 11.5 grams of $FeCl_3$?

Final Answer (include units and substance)

4. How many moles are in 97.8 grams of $Ra(OH)_2$?

Final Answer (include units and substance)

Practice Time – moles to grams problems

5. Convert 1.56 moles of C_6H_6 to grams.

Final Answer (include units and substance)

6. How many grams are in 0.11 moles of $Cu(OH)_2$?

Final Answer (include units and substance)

7. What is the mass (in grams) of 3.2 moles of $C_6H_4F_2$?

Final Answer (include units and substance)

Guiding Question:

Do Now:

Important Definitions and Equations:

Notes:

Mole Ratio: The ratio in which reactants have to combine to form the maximum amount of products.

You determine the mole ratio by looking at the coefficients in the balanced chemical equation.

Example:

$$2CH_4O + 3O_2 \rightarrow 2CO_2 + 4H_2O$$

How many moles of carbon dioxide will you make if you react 4 moles of O_2?

Response:

18 Step up to the line
Mole Ratios

Read this!

Scientists sometimes don't need to reference mass or moles directly. Instead they want to compare the components of substances for various reasons -- toxicity, effectiveness of a specific part of a compound, cost, and so on. Scientists use a concept that has been discussed in your math class to do this: ratios. Using ratios, or as a chemist would say, *mole ratio*, one can compare different elements or parts of compounds to the whole compound or other parts within a compound. We will look at this in the section that follows.

MODEL 1 - Ammonia

1. In model 1, what atoms are there and how many of each?

2. Using this, write a possible chemical formula for this compound.

3. Remember back to math class where you could relate quantities to each other in a situation using ratios. For example, your class has 1 teacher for about 32 students, or a ratio of 1:32 (and don't think the odds are in your favor). Write a ratio for the atoms in this compound.

4. If you had two molecules of ammonia, how many of each atom do you have?

5. Compare question 4 to question 3. Do these two have the same ratio? Explain your answer.

6. If you have 1 million molecules, how many of each atom do you have?

    a. How does this relate to the ratio in question 3?

    b. Explain how a ratio can help you relate amounts of atoms and molecules.

7. If you have 602 sextillion molecules of ammonia, how much do you have? (*HINT*: it is one word)

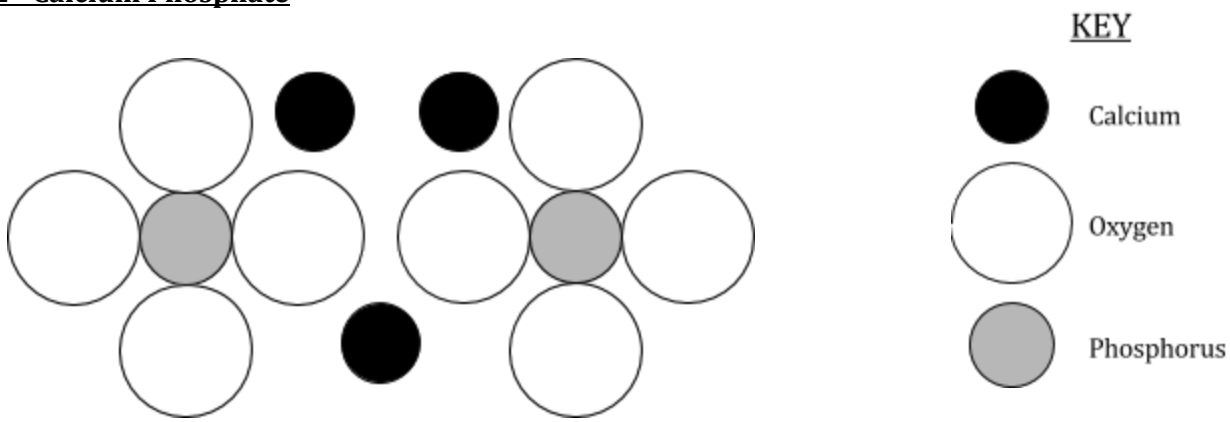
8. Complete the statement and ratio below:

    In one mole of ammonia, there are _____ nitrogen atom(s) and _____ hydrogen atom(s).

    _____ NH_3 : _____ N: _____ H

    _____ : _____ : _____

MODEL 2 - Calcium Phosphate



9. In model 2, what atoms are there and how many of each?

10. Using this, write a possible chemical formula for this compound.

11. The technical formula for calcium phosphate is $Ca_3(PO_4)_2$. How does this compare to your formula? Do they still have the same number of atoms of each? Explain.

12. Write a ratio for the atoms in this compound.

13. If you have 2 moles of calcium phosphate,
    a. how many moles of calcium do you have?

    b. how many moles of phosphorus do you have?

    c. how many moles of oxygen do you have?

14. Explain how you can use mole ratios to determine the amount of atoms in a sample.

Apply It

Now that we have this idea of mole ratios, we are going to apply it to conversions using the same process and set up that we did for converting between moles and grams.

1. You have 3.72mol H_2O. How many moles of hydrogen are in this sample?

   Step 1: Road Map

   Step 2: Determine ratio

   You are solving for hydrogen. How many moles of hydrogen are in 1 mole of water? Write the ratio.

   Step 3: Set-up train track

   What you are given goes in the first spot. Drag the units and substance diagonally to cancel units. Place what you want on the top.
   Now, match the ratio numbers from before and place them in the correct spots on the train track.

   Step 4: Solve

   Multiply across the top and divide by what is on the bottom.

   = _____

   (Include units and substance)

2. A sample of lithium sulfide, Li_2S, has 0.63mol. How many moles of lithium are in this sample?

   Step 1: Road Map

   Step 2: Determine ratio

   You are solving for hydrogen. How many moles of hydrogen are in 1 mole of water? Write the ratio.

   Step 3: Set-up train track

   What you are given goes in the first spot. Drag the units and substance diagonally to cancel units. Place what you want on the top.
   Now, match the ratio numbers from before and place them in the correct spots on the train track.

   Step 4: Solve

   Multiply across the top and divide by what is on the bottom.

   = _____

   (Include units and substance)

3. You need 0.32mol Na for a reaction study. How much sodium phosphide, Na_3P, do you need for it?

Step 1: Road Map

Step 2: Determine ratio

You are solving for hydrogen. How many moles of hydrogen are in 1 mole of water? Write the ratio.

Step 3: Set-up train track

What you are given goes in the first spot. Drag the units and substance diagonally to cancel units.
Place what you want on the top.
Now, match the ratio numbers from before and place them in the correct spots on the train track.

Step 4: Solve

Multiply across the top and divide by what is on the bottom.

= _____

(Include units and substance)

Practice

1. In a 2.43mol sample of methane, CH_4, how many moles of carbon are there?

2. If you have 0.64mol nitrogen in a sample of ammonia, NH_3, how many moles of hydrogen are there?

3. 1.72mol carbon dioxide, CO_2, has how many moles of carbon?

4. How many moles of hydrogen are in 0.89mol CH_3OH?

Guiding Question:

Do Now:

Important Definitions and Equations:	**Notes:**

Response:

19 Run the Race
Stoichiometry Conversions

Purpose: To utilize mole to mole conversions with gram and mole conversions.

Example 1

In a 25g sample of sodium sulfide (Na_2S), determine how many grams of sulfur are in the sample.

Step 1: Road Map

Step 2: Determine ratio.

Step 3: Determine molar masses

Step 4: Set-up train tracks

Step 5: Solve

Multiply across the top and divide by what is on the bottom.

= _____

(Include units and substance)

Example 2

How much silicon dichloride, $SiCl_2$, is needed (in grams) to have 64g silicon in the sample?

Step 1: Road Map

Step 2: Determine ratio

Step 3: Determine molar masses

Step 4: Set-up train tracks

Step 5: Solve

Multiply across the top and divide by what is on the bottom.

= _____

(Include units and substance)

Practice

1. In a 2.5g sample of $PbSO_4$, how many grams of oxygen are there?

2. In a 2.5g sample of $PbSO_4$, how many grams of sulfur are there?

3. In a 2.5g sample of $PbSO_4$, how many grams of lead are there?

4. There is 87.5g of KCl (potassium chloride), how much potassium is there in grams?

5. There is 87.5g of KCl (potassium chloride), how much chlorine is there in grams?

6. How many grams of carbon are in 3.2g CH_3OH?

7. How many grams of hydrogen are in 3.2g CH_3OH?

8. How many grams of oxygen are in 3.2g CH_3OH?