Name Filled in Notes Hour

CHM CON B Unit 10 Packet: The Mole Unit

NOTE: You MUST bring a SCIENTIFIC CALCULATOR with you to class EVERY DAY for this entire unit!!!

Learning Goals:

1. I can determine molar mass using a periodic table
2. I can calculate moles, atoms or grams of a substance given moles, atoms or grams
3. I can calculate percent composition given the chemical formula
4. I can calculate the empirical formula given percent composition data or mass data
5. I can calculate the molecular formula given the empirical formula and molecular formula mass
6. I can calculate the molecular formula given the percent composition and molecular formula mass
7. I can correctly round my answers to the correct number of significant figures

VOCABULARY (I can define/describe the following terms in my own words)

- Experimental Answer
- Molar Mass
- Mole
- Percent composition
- Percent error
- Significant figures
- Theoretical answer

Significant Figure Notes

Information: Significant Figures

Scientific Notation can be a very nice way of getting rid of unnessary zeros in a number. For example, consider how convenient it is to write the following numbers:

32,450,000,000,000,000,000,000,000,000,000,000 = $3.245X10^{34}$

0.000000000000000127= $1.27X10^{-16}$

There are a whole lot of zeros in the above numbers that are really NOT needed. As another example consider the affect of changing units:

21,500 meters = 21.5 kilometers

0.00582 meters= 5.82 millimeters

Notice that zeros in "21,500 meters" and in "0.00582 meters" are not really needed when the units change. Taking these examples into account, we can introduce three general rules.

1. zeros at the beginning of a number are never significant (important)
2. Zeros at the end of a number are NOT significant unless... (you'll find our later)
3. Zeros that are between two nonzero numbers are ALLWAYS significant.

Therefore, the number 21,500 has three significant figures: only three of the digits are important— the two, the one, and the five. The number 10, 210 has four significant figures because only the zero at the end is considered not significant. ALL of the digits in the number 10,005 are significant because the zeros are in between two non zero numbers (Rule #3).

Examples:

1) Verify that each of the following numbers contains four significant figures. Circle the digits that are significant

a) 0.00004182 b) 494,100,000 c) 32,010,000,000 d) 0.00008002

2) How many significant figures are in each of the following numbers?

5 a) 0.000015045 2 b) 4,600,000 4 c) 2406

1 d) 0.000005 6 e) 0.0300001 2 f) 12,000

Information: The exception to Rule #2

There is 1 exception to the second rule. Consider the following measured values.

It is 1200 miles from my town to Atlanta
It is 1200.0 miles from my town to Atlanta.

The quantity "1200.0 miles" is more precise than "1200 miles". The decimal point in the quantity "1200.0 miles" means that it was measured very precisely— right down to the tenth of a mile. Therefore, the complete version of Rule #2 is as follows:

Rule #2: Zeros at the end of a number are not significant unless there is a decimal point in the number. A decimal point anywhere in the number makes zeros at the end of a number significant.

Examples:

1)

0.0000007290 ⟸ This zero **IS** significant because it is at the end of the number **and there is a decimal point in the number.**

2) Verify that each of the following numbers contain five significant figures. Circle the digits that are significant.

a) 0.00030200 b) 200.00 c) 2300.0 d) 0.0000320000

3.) How many significant figures are there is each of the following numbers?

6 a) 0.000201000 5 b) 23,001,000 3 c) 0.0300

7 d) 24,000,410 7 e) 2400.100 2 f) 0.000021

Significant figures are... any digits in a measurement that are known with certainty, plus 1 final digit that is somewhat uncertain or estimated

All nonzero digits are significant.

Some zeros are significant, others are NOT.

The Ocean Trick:

Decimal Present = Pacific
Start counting sig figs from the 1st nonzero # on Pacific side. →
0.0005782 (4)
0.040611 (5)
500.25 (5)

Decimal Absent = Atlantic
Start counting sig figs from the 1st nonzero number on Atlantic side. ←
57,800,000 (3)
4,060 (3)
10,045 (5)

Information: Rounding Numbers

In numerical problems it is often necessary to round numbers to the appropriate number of significant figures. Consider the following examples in which each number is rounded so that each of the contains 4 significant figures.

a) 42,008,000 → 42,010,000

b) 12,562,425,217 → 12,560,000,000

c) 0.00017837901 → 0.0001784

d) 120 → 120.0

Rules for Rounding:

1. Identify the number of significant figures you should round your number to.
2. Underline the last digit.
3. Draw an arrow under the digit to the right.
4. If the number to the right is 5 or larger you round your last significant figure up, if the number is lower do not change your last significant figure. (*Note when rounding a 9 up you must change more than 1 digit)
5. If your number **does not have** a decimal then change every number after your underlined number to a zero (0)
6. If your number **does have** a decimal then every number after your underlined number should be dropped.
7. If your number does not have enough significant figures you may need to add a decimal and/or add zeros or write your answer in scientific notation to maintain your place value.

Examples:

1) Round the following numbers so that they contain 3 significant figures.

a) 173,792	b) 0.0025021	c) 0.0003192	d) 30
174,000	0.00250	0.000319	30.0

2) Round the following numbers so that they contain 4 significant figures.

a) 249,441	b) 0.00250122	c) 12,049,002	d) 0.00200210
249,400	0.002501	12,050,000	0.002002

Significant Figures Concept Check #1

1) Determine the number of significant figures in each of the following:

   _______a) 605.03g _______b) 0.8030L _______c) 450m _______d) 350.0 K

2) Write "two hundred meters" in numerical form with the indicated number of significant figures. (NOTE: You cannot use any unit other than meters.)

   a) 1 __________ b) 2 __________ c) 3__________ d) 5 __________

3) Round of each of the following measurements to the indicated number of significant figures.

   ______________a) 57.96 cm to 3 significant figures ______________b) 504004 mL to 3 significant figures

   ______________c) 11,2045 m to 4 significant figures ______________d) 0.043694 kg to 3 significant figures

   ______________e) 12.04 L to 5 significant figures

Significant Figures Rules for Division & Multiplication

Writing an answer in correct sig figs when multiplying or dividing:

(1) Count number of sig figs in <u>EACH</u> number to be multiplied or divided.

(2) Determine which number has the <u>LEAST</u> number of sig figs → this is how many sig figs your <u>answer</u> must have

(3) Round answer to correct number of sig figs

Examples: $\frac{4560\ (3)}{14\ (2)} = 325.7142857 = \underset{(2)}{330}$ $\quad \underset{(3)}{13.1} \times \underset{(5)}{1.2039} = 15.77100 = \underset{(3)}{15.8}$

Significant Figures Concept Check #2

Calculate the following math problems and round your answers so they have the correct number of significant figures.

1. (240,900)(120.0) = ______________________________

2. 340/12.5 = ______________________________

3. $(2.450 \times 10^6)(2.0 \times 10^6)$ = ______________________________

4. $(5.369 \times 10^{12})/(2.89 \times 10^7)$ = ______________________________

**Note: There are DIFFERENT rules when adding and subtracting numbers with different amounts of sig figs, but we won't do much adding or subtracting in of numbers in this unit, so we will not learn that set of rules.

Notes on Accuracy – Using Percent Error

I. Percent Error is used to determine accuracy or how close our lab data is to the actual, correct answer (often called the theoretical answer). The equation is:

$$\frac{|\text{Theoretical Answer} - \text{Experimental Answer}|}{\text{Theoretical Answer}} \times 100\%$$

A. WITHOUT LOOKING, each group member will estimate the number of white bricks there on the east wall (2 half bricks in a row will count as one brick overall). Record each estimate in the spaces below.

Estimated Number of Bricks

_____ _____ _____ _____ Average: _____

Actual number of bricks: ______

Calculate the percent error in the space below.

B. Obtain a bag of M&M's. Estimate how many M&M's are in a bag without opening the bag.

Estimated Number of M&M's

_____ _____ _____ _____ Average: _____

Actual number of M&M's: ______

Calculate the percent error in the space below.

C. Without counting, estimate the number of <u>watches</u> in the room.

Estimated Number of watches

_____ _____ _____ _____ Average: _____

Actual number of watches: ______

Calculate the percent error in the space below.

Answer the following questions about percent error. Be sure to answer with the correct number of significant figures.

1. A student conducted an experiment to find the density of gold. Gold's density is 19.3 g/cm^3. His calculations were 18.8 g/cm^3, 15.2 $g/cm^3$and 19.6 g/cm^3. Find his percent error, showing work below.

2. Ms. Lutz used to work at Cedar Point and worked the Guess My Weight game. One day, Mr. Hoshal came by and Ms. Lutz took three guesses: 190 lbs, 205 lbs and 250 lbs. Mr. Hoshal's correct weight is 240 pounds of chiseled muscular perfection. What was Ms. Lutz's percent error, showing work below? If she was within 10% error, no prize was given. Did Mr. Hoshal win a prize?

3. Conduct your own experiment. Explain what you are doing and record your data, then determine your percent error, showing work below.

Molar Mass Notes

What is a mole? A chemistry unit (aka the chemists' dozen
1 dozen = 12 units (cookies, donut) 1 mole = 6.02×10^{23} units (atoms, molecules)

The molar mass is the mass of 1 mole of any element or compound.

For example:

One mole of oxygen has a mass of 15.999 grams. So oxygen's molar mass is 15.999 grams.

How do we find the molar mass?

① Look up mass of an element on periodic table and round to hundredth (2nd # after decimal)
② For a compound, multiply masses by subscripts & add all masses together

Examples:

Ag

mass on PT = 107.87 g

Molar mass = 107.87 g/mol

H_2O

H = 1.0079 ≈ 1.01
O = 15.999 ≈ 16.00
2(1.01) = 2.02
1(16) + = 16
18.02 g/mol

$AgCl_2$

Ag = 1(107.87) = 107.87
Cl = 2(35.45) + 70.9
178.77 g/mol

$(NH_4)_2SO_4$

N = 2(14.01) = 28.02
H = 8(1.01) = 8.08
S = 1(32.07) = 32.07
O = 4(16.00) + 64.00
132.17 g/mol

$MgCO_3$

Mg = 1(24.31) = 24.31
C = 1(12.01) = 12.01
O = 3(16.00) = 48 +
84.32 g/mol

$Cr(CH_3COO)_2$

Cr = 1(52.00) = 52.00
C = 4(12.01) = 48.04
H = 6(1.01) = 6.06
O = 4(16.00) + 64
170.1 g/mol

Molar Mass Concept Check

Find the molar mass of the following compounds

1. $KClO_3$

2. $CH_3CH_2CH_2CH_2CH_3$

3. $C(H_2PO_4)_2$

4. CH_3COOHP

5. $KMnO_4$

Percent Composition Notes

What is percent composition? The percent by mass of each element in the compound.

Example: How to calculate the percent composition by mass of the formula $MgCl_2$.

1. Find the molar masses of both elements.	1 Mg = 24.31g 2 Cl = 2 x 35.45g = 70.90g
2. Find the total molar mass of the entire compound.	$MgCl_2$ = 95.21g
3. Divide the molar mass of magnesium by the total molar mass of the compound. Multiply by 100% to change to a percent.	$\frac{24.31g}{95.21g}$ = 0.2553 x 100 = 25.53%
4. That represents the percent of magnesium contained in the compound.	
5. Divide the molar mass of chlorine by the total molar mass of the compound.	$\frac{70.90g}{95.21g}$ = 0.7447 x 100 = 74.47%
6. That represents the percent of chlorine contained in the compound.	
7. You have just found the percent composition by mass of $MgCl_2$.	

Example Problem:

Your bag of M&M's represents a chemical formula. Each color is a different element represented in the M&M bag. For example, if your bag has 2 red M&M's and 20 total M&M's, then the percent composition of red M&M's would be 10%. Find the percent composition by number of M&M's. Show your work for all problems below.

Determine the percent composition by mass of each of the following compounds below. Show all work including each fraction like in the example problem. Be sure to follow the significant figures rules!

1. K_2SO_4

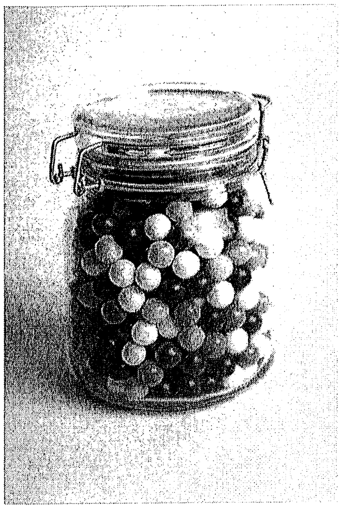
2. H_2O

3. $AgNO_3$

4. $(NH_4)_2S$

5. Fe_2O_3

Percent Composition of Gum Inquiry Lab



Each group will be given a piece of gum. Your job is to figure out what percent of that gum is soluble and what percent is not soluble. You must show calculations and explain your procedure. You may ask questions, but you may not get answers! Have your procedure ready for the next class. Good Luck!

Empirical Formulas

Information: Calculating Empirical Formula

When you know the percent composition of each element in a compound you can calculate the empirical formula of that compound. The following example will illustrate how to do this.

Example 1: A certain compound is 30.4% nitrogen and 69.9% oxygen by mass. What is the empirical formula of the compound?

Step #1: Divide each % by the molar mass from the Periodic Table:

For Nitrogen: $\frac{30.4}{14.0} = 2.17$ For Oxygen: $\frac{69.9}{16.0} = 4.35$

From the periodic table for nitrogen and oxygen

Step #2: Find the ratio of nitrogen to oxygen. To do this, find the smallest answer obtained in step #1. In this example, the smallest answer is 2.17. Now divide each of your answers to step #1 by this smallest number. In this example, you should divide each answer by 2.17:

For Nitrogen: $\frac{2.17}{2.17} = 1.00$ For Oxygen: $\frac{4.35}{2.17} = 2.00$

Step #3: Write the formula. The answers from step #2 are the subscripts in the formula. The formula for our example is NO_2.

*NOTE: If in step #2 you get something like Nitrogen= 1.00 and Oxygen= 2.50 then the formula you write in step #3 would be $NO_{2.5}$.. This doesn't make any sense because all subscripts MUST be whole numbers. You would need to double each subscript. The formulas would be Na_2O_5

Empirical Formula Guided Practice

1) Find the empirical formula for a compound that contains 82.4% nitrogen and 17.6% hydrogen.

$N = \frac{82.4}{14.0} = 5.89$ $H = \frac{17.6}{1.01} = 17.4$ $\frac{17.4}{5.89} = 2.95 \approx 3$ $\frac{5.89}{5.89} = 1$

$\boxed{\text{So } NH_3}$

2) What is the empirical formula of a compound whose percent composition by mass is 85.7% carbon and 14.3% hydrogen?

$C = \frac{85.7}{12.01} = 7.14$ $H = \frac{14.3}{1.01} = 14.16$ $\frac{14.16}{7.14} = 1.98 \approx 2$ $\frac{7.14}{7.14} = 1$

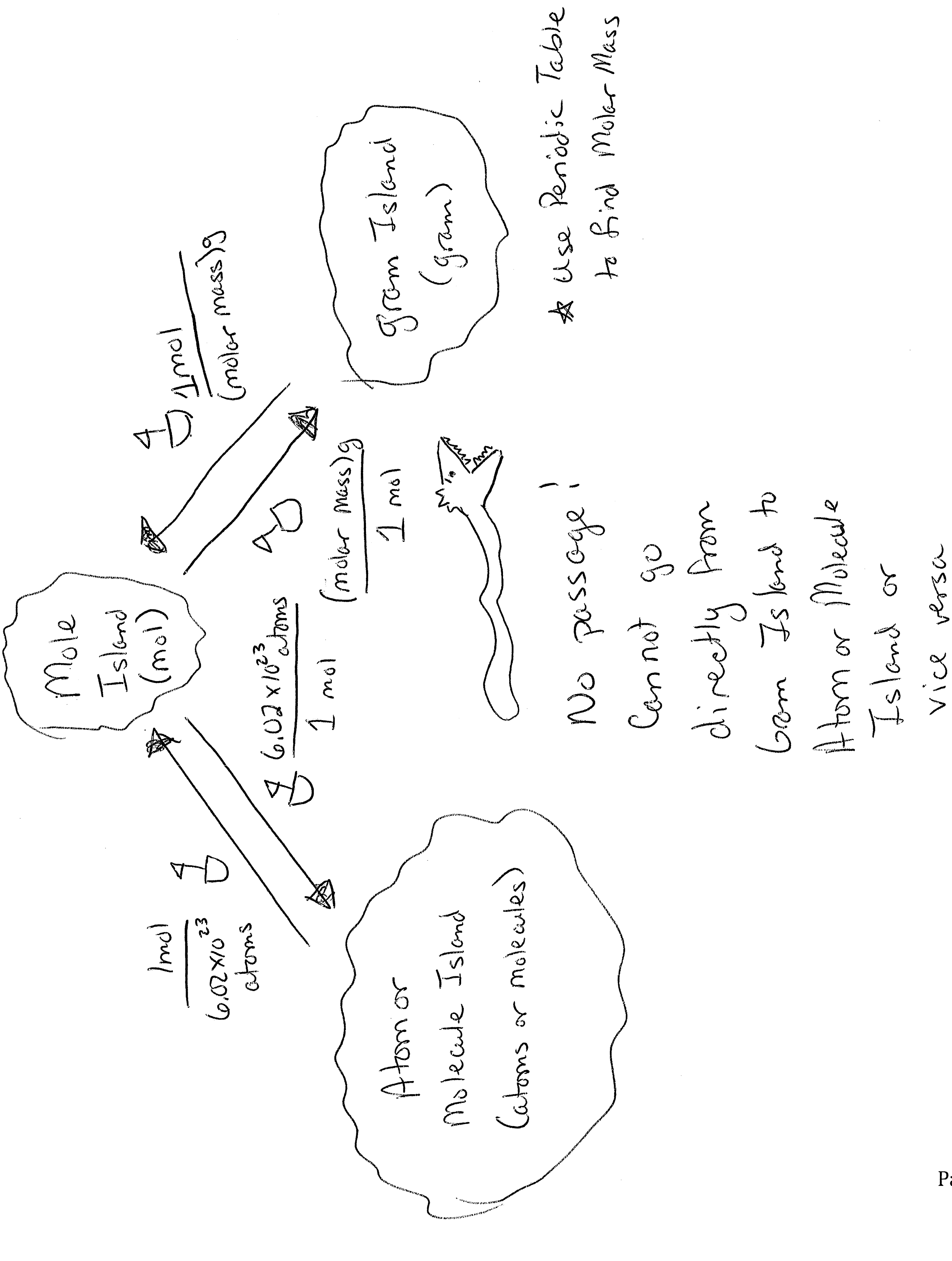
$\boxed{\text{So } CH_2}$

3) What is the empirical formula of a compound made up of 22.1% aluminum, 25.4% phosphorus and 52.5% oxygen?

$Al = \frac{22.1}{26.98} = 0.819$ $P = \frac{25.4}{30.97} = 0.820$ $O = \frac{52.5}{16} = 3.28$ $\frac{3.28}{0.819} = 4.004 \approx 4$ $\frac{0.820}{0.819} = 1.001 \approx 1$

$\frac{0.819}{0.819} = 1$ $\boxed{\text{So } AlPO_4}$

Treasure Map to Mole Island!!



= Given   Try to find

Using Mole Island Guided Practice

1. 25 moles of H_2O are needed for a lab. How many $\boxed{\text{grams of } H_2O}$ should I measure out?

$H = 2(1.01) = 2.02$
$O = 1(16) = +16$
18.02 g/mol

$$\frac{25 \cancel{mol} \ H_2O \;\Big|\; 18.02\ g}{\;\Big|\; 1\ \cancel{mol}} = 450.5 g\ H_2O$$

450 g H_2O

2. 1.5 moles of HCl is needed. How many grams to do we need?

on own

3. I have 0.30 moles of $CaCl_2$. How many $\boxed{\text{"molecules"}}$ do I have?

$$\frac{0.30 \cancel{mol}\ CaCl_2 \;\Big|\; 6.02 \times 10^{23} \text{ molecules}}{\;\Big|\; 1\ \cancel{mol}} = 1.806 \times 10^{23} \text{ molecules } CaCl_2$$

1.8×10^{23} molecules $CaCl_2$

4. How many "molecules" are in 0.042 moles of KOH?

on own

5. Convert 52 g of NaCl to $\boxed{\text{MOLECULES.}}$

Na = 1(22.99) = 22.99
Cl = 1(35.45) = + 35.45
58.44 g/mol

$$\frac{52 \cancel{g}\ NaCl \;\Big|\; 1\ \cancel{mol} \;\Big|\; 6.02 \times 10^{23} \text{ molecules}}{\;\Big|\; 58.44 \cancel{g} \;\Big|\; 1\ \cancel{mol}} = 5.36 \times 10^{23} \text{ molecules NaCl}$$

5.4×10^{23} molecules NaCl

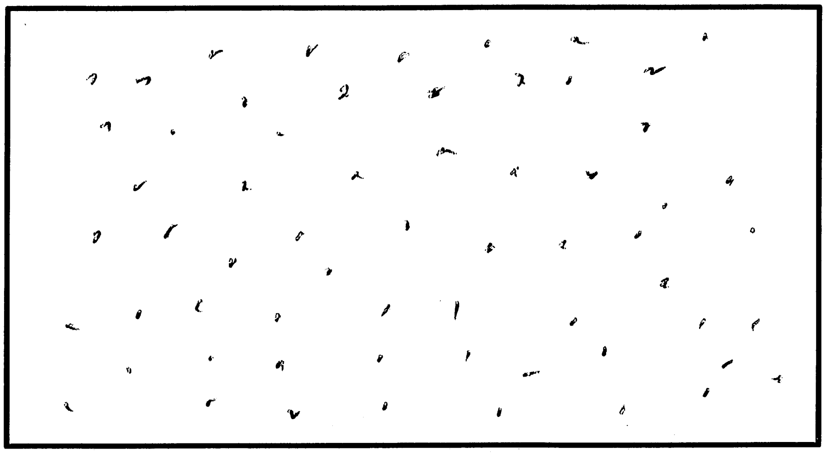
★ Multiply all that's on top
★ Divide by all on bottom

How Big is a Mole?

Follow the oral instructions for using the space below to find out how big a mole is.

Individual rate 366
(dots/min)

Class rate ____________
(dots/min)



61 dots
×6
366

Complete the following:

1. The amount of time (number of years) it would take you to complete 1 mole of dots and the rate you recorded above.

$$\frac{1\text{ mol}}{} \cdot \frac{6.02 \times 10^{23}\text{ dots}}{1\text{ mol}} \cdot \frac{1\text{ min}}{366\text{ dots}} \cdot \frac{1\text{ hr}}{60\text{ min}} \cdot \frac{1\text{ day}}{24\text{ hours}} \cdot \frac{1\text{ year}}{365\text{ days}} = 3.13 \times 10^{15}\text{ years}$$

2. The amount of time (number of years) it would take the entire class to complete 1 mole of dots at the class rate recorded above.

on own

The Mole in Perspective:

3. If every single person on this planet (about 7×10^{9}) could eat 1 pizza every second, how many years would it take us to collectively eat 1 mole of pizza?

on own

Steps for Solving Unit 8 Problems

	Write the steps you must follow to solve the following problems	Then find an example problem from your notes and show how to apply the steps
Molar Mass		
Percent Composition		
Empirical Formulas		

The mass of one mole of any element or compound.	A calculated value or from a reference book, this value is correct.	Any digits in a measurement that are known with certainty, plus one final digit that is somewhat certain or estimated.	A chemistry counting uni one is equal to 6.02×10^{23}.
A value calculated using lab data.	The percentage by mass of each element in a compound.	Used to determining the accuracy or how close our lab data is to the actual correct answer.	