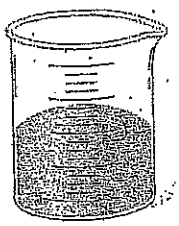
Moles Inquiry Activity

No… Not this kind of mole!

Purpose/Objective
Understand the relationship between the mass of an element and the number of particles (the mole).

The Model



Beaker 1
55.8 g of iron
1 mole of iron
6.02×10^{23} atoms of iron

Beaker 2
111.6 g of iron
2 mole of iron
12.04×10^{23} atoms of iron

Beaker 3
112 g of cadmium
1 mole of cadmium
6.02×10^{23} atoms of cadmium

Reviewing the Model

1. Which beaker (1 or 2) has more **atoms** of iron?
2. How many **grams** of iron are in
   Beaker 1? _____
   Beaker 2? _____
3. How many **moles** of iron are in:
   Beaker 1? _____
   Beaker 2? _____
4. How many **atoms** of iron are in
   Beaker 1? _____
   Beaker 2? _____

Exploring the Model

5. Write an equality statement between grams of iron and moles of iron in Beaker 1.

   Write an equality statement between grams of iron and moles of iron in Beaker 2.

   Is there a relationship between the equality for Beaker 1 and Beaker 2?

6. Write the equality between grams of cadmium and moles of cadmium.

7. Write the equalities above (problems 5 and 6) as conversion factors.

   Iron: Cadmium:

8. Compare this information for each element above to the information on the periodic table. Is there a relationship between the information given and your answers to number 7?

Evaluate Your Understanding

9. If you are given a mole of atoms of each of the following, what would the mass (grams) be?
   a. Carbon

   b. Potassium

   c. Chlorine

10. So, how many particles (atoms/molecules/bicycles, etc) in one mole? _____

******CHECK YOUR ANSWERS BEFORE MOVING ON TO NUMBER 11******

Exercising Your Knowledge

11. Different elements, their masses and numbers of particles and moles are listed below. Complete the table with the missing information for each element. **DO NOT USE A CALCULATOR.**

Element	Mass of Sample	Number of Particles in Sample	Number of Moles in Sample
Magnesium		6.02×10^{23} atoms	1.00 moles
Arsenic	150. grams		
	23.0 grams	6.02×10^{23} atoms	
Lithium	13.9 grams		
	34.3 grams		0.25 moles
Boron		3.01×10^{23} atoms	
Silicon	56.2 grams		
	40.4 grams	1.204×10^{24} atoms	
Iodine			0.25 moles
	100. grams		0.50 moles

12. If you have two different samples, the first with an actual mass of 100.0 g of silver and the second with an actual mass of 100.0 g of gold, which sample has more atoms (or are they the same)? Explain your answer.
    Hint: Set up conversion factors for each substance.

13. You have half a mole of M & M's, how many M & M's do you have?

14. If you have 3.01×10^{23} apples, how many moles of apples do you have?

Worksheet: Mole Problems Name_____

Part 1: Molar Mass

Use the periodic table to find the molar masses of the following.

HCl K_2CO_3

$Ca(OH)_2$ Na_3PO_4

Part 2: Mole Conversions

Work each of the following problems. SHOW ALL WORK.

1. How many atoms are in 6.2 moles of aluminum?

2. Convert 5.3×10^{25} molecules of CO_2 to moles.

3. How many formula units of sodium acetate are in 0.87 moles of sodium acetate?

4. Convert 3.55 moles NaCl to formula units.

Moles to Particles (atoms or molecules) **NAME:** _____

1. How many molecules are in 2.00 moles of H_2O?

2. How many moles are in 8.30×10^{23} molecules of H_2O?

3. How many atoms are in 1.87 moles of He?

4. How many formula units are in 1.50 moles of $HgCl_2$?

5. How many molecules are in 2.50 moles of O_2?

6. How many moles are in 1.23×10^{50} molecules of $C_2H_4O_2$?

7. How many moles are in 5.25×10^{25} formula units of chromium (IV) sulfate?

8. How many moles are in 8.11×10^{20} formula units of calcium hydroxide?

Moles, Molecules, and Grams Worksheet

1) How many molecules are there in 24 grams of FeF_3?

2) How many molecules are there in 450 grams of Na_2SO_4?

3) How many grams are there in 2.3×10^{24} atoms of silver?

4) How many grams are there in 7.4×10^{23} molecules of $AgNO_3$?

5) How many grams are there in 7.5×10^{23} molecules of H_2SO_4?

6) How many molecules are there in 122 grams of $Cu(NO_3)_2$?

7) How many grams are there in 9.4×10^{25} molecules of H_2?

8) How many molecules are there in 230 grams of $CoCl_2$?

Name:_____

Molar Conversions: Remember the Bridges!

1) How many moles are present in 34 grams of $Cu(OH)_2$?

2) How many moles are present in 2.45×10^{23} molecules of CH_4?

4) How many grams are there in 3.4×10^{24} molecules of NH_3?

5) How much does 4.2 moles of $Ca(NO_3)_2$ weigh?

6) 3.50 grams of Magnesium Oxide would contain how many formula units?

7) How many grams does 0.500 moles of CuBr weigh?

8) How many molecules are there in 0.655 moles of C_6H_{14}?

9) How many moles are there in 2.35×10^{24} molecules of water?

10) 6.35×10^{23} molecules of hydrochloric acid would be how many grams?

Name _____ Period _____ Date _____

Mixed Molar Conversions

1. How many moles are in 1.20×10^{25} formula units of potassium sulfate?

Formula:	Molar mass:
Answer:	

2. You need 2.5 moles of Iridium for an experiment. How many atoms of iridium is this?

Formula:	Molar mass:
Answer:	

3. 380 g of carbon trifluoride would equal how many moles?

Formula:	Molar mass:
Answer:	

4. There are 3.20×10^{22} atoms of copper in the outer shell of pennies. How many grams of copper is this?

Formula:	Molar mass:
Answer:	

5. If you pump 408.8 g of hydrofluoric acid into a tank, how many molecules of hydrofluoric acid are you using?

Formula:	Molar mass:
Answer:	

6. If you have 0.975 moles of calcium phosphate , how many grams of calcium phosphate do you have?

Formula:	Molar mass:
Answer:	

Name:_____

Limiting Reactants and % Yield

This assignment will help you gain perspective regarding the importance of optimizing and scaling up a chemical reaction for commercial purposes. In addition to optimizing the chemistry for the production of the product, you must be cognizant of a number of other factors: financial, regulatory compliance, legal, etc. Your goal is to create the most profitable process, while balancing all of the other factors.

Background

A chemical manufacturer wants to try a new process for making a highly refined form of nickel(II) oxide from $Ni(NO_3)_2$ and NaOH. The product is sold for use in making rechargeable batteries (NiMH) for use in high tech devices. The raw materials cost $2,000 per ton for $Ni(NO_3)_2$ and $50 per ton for NaOH.

THE REACTION (be sure to balance it!)

$$Ni(NO_3)_2 + NaOH \rightarrow NiO + NaNO_3 + H_2O$$

METHOD 1

The old method (call it Method 1) uses equal masses of NaOH and nickel nitrate, and has a 95% yield. However, it costs $200 per ton of product generated to refine the product and process wastes.

METHOD 2

The first new method (Method 2) uses twice the mass of nickel nitrate as NaOH, and has a 90% yield, but refinement & waste processing costs $25 per ton.

METHOD 3

The other new method (method 3) uses five times the mass of nickel nitrate as NaOH, has a 99% yield, and refinement/waste processing only costs $10 per ton.

You have been hired as a consulting firm to help the manufacturer decide whether to adopt one of the new processes, and if so, which one to choose.
What is your advice to the manufacturer? How did you reach your answer?

In your group, the person with the lowest # birth month (using day of the month as a tie-breaker) will be the "manager", whose job is to keep the decision process focused and work toward making a reasonable decision. The person with the highest # birth month is the "technician" who will actually perform any needed calculations; and the other person will be the "skeptic", whose job is to question assumptions and make sure everything works out.

At the end of the consultation, one of you may be chosen to make your "sales pitch" for the decision you've reached. Be sure each member of the group understands the decision!

Questions To Ponder:

1. What chemistry challenges do you need to work out for this job?
2. What criteria will be important in making your recommendation?
3. How will you evaluate those criteria?
4. Are there other criteria that could be used? If so, what are they and how can you assess or rank their value?

5. What would be the "ideal" quantities to use, to make 1 ton of salable product?

Your Pitch:

Put together a 2-4 minute sales pitch to justify your approach and gain approval from the management team. Include in your pitch:

1. Key elements to the success of the approach include: The limiting reactant, refining of product required/cost and disposal of waste products, including costs.

2. The primary influence on the management team is likely to be financial. Include a full financial analysis to support your choice as the best alternative. The second greatest influence on the management team will likely be any potential compliance issues or legal ramifications related to waste and disposal.

3. Additional Downstream issues analysis including the impact of waste products and potential environmental impacts should be mitigated in your presentation.

CONSULTING TOOLS:

Balanced Reaction

$Ni(NO_3)_2 + NaOH \rightarrow NiO + NaNO_3 + H_2O$

Financial Analysis:

Raw Materials

Method	Quantity NaOH	Quantity Nickel Nitrate	% Yield	Refinement and Waste Processing
1	100 metric Ton NaOH	1x NaOH	95%	$200/ton
2	100 metric Ton NaOH	2x NaOH	90%	$25/ton
3	100 metric Ton NaOH	5x NaOH	99%	$10/ton

1 metric ton = 1000 kg