**Unit 8: Moles and Solutions Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |
| --- |
| **Learning Targets** |
| 1. *I CAN report my answer to a calculation in the correct number of significant digits \*review*
 |
| 1. *I CAN write a given value in scientific notation \*review*
 |
| 1. I CAN define the mole and describe it’s use in chemistry
 |
| 1. *I CAN solve a problem using dimensional analysis (multi-step conversions) \*review*
 |
| 1. I CAN calculate the molar mass (formula weight) of a compound
 |
| 1. I CAN describe a hydrate and calculate its molar mass
 |
| 1. I CAN convert in between mass, moles, and atoms/molecules.
 |
| 1. I CAN calculate the percent composition of an element in a compound
 |
| 1. I CAN use data collected in lab to determine the empirical formula for a compound
 |
| 1. I CAN use data collected in lab to determine the molecular formula for a compound
 |
| 1. I CAN describe the components of a solution (solute, solvent)
 |
| 1. I CAN describe the solubility of a compound in water using a saturation curve (unsaturated, saturated, or supersaturated)
 |
| 1. I CAN calculate the concentration of a solution (moles and mass of solute, volume of solvent, molarity)
 |
| 1. I CAN calculate the amount of water needed to dilute a solution
 |

|  |
| --- |
| Chemistry Important Dates!  |
| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| March 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |

No… Not this kind of mole!

**Notes on What is a Mole?**

**Inquiry into “The Mole”**

**Purpose/Objective**

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

**The Model**

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**Use “The Model” on the previous page to answer the following questions:**

1. Which beaker (1 or 2) has more **atoms** of iron? \_\_\_\_\_\_\_\_\_\_\_\_
2. How many **grams** of iron are in

Beaker 1? \_\_\_\_\_\_\_\_\_\_

Beaker 2? \_\_\_\_\_\_\_\_\_\_

1. How many **moles** of iron are in:

Beaker 1? \_\_\_\_\_\_\_\_\_\_

Beaker 2? \_\_\_\_\_\_\_\_\_\_

1. How many **atoms** of iron are in

Beaker 1? \_\_\_\_\_\_\_\_\_\_

Beaker 2? \_\_\_\_\_\_\_\_\_\_

**Exploring the Model**

1. 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?

1. Write the equality between grams of cadmium and moles of cadmium.
2. Write the equalities above (problems 5 and 6) as conversion factors.

Iron: Cadmium:

1. 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**

1. If you are given a mole of atoms of each of the following, what would the mass (grams) be?
2. Carbon
3. Potassium
4. Chlorine
5. So, how many particles (atoms/molecules/bicycles, etc) in one mole? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercising Your Knowledge**

1. 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 x 1023 atoms | 1.00 moles |
| Arsenic | 150. grams |  |  |
|  | 23.0 grams | 6.02 x 1023 atoms |  |
| Lithium | 13.9 grams |  |  |
|  | 34.3 grams |  | 0.25 moles |
| Boron |  | 3.01 x 1023 atoms |  |
| Silicon | 56.2 grams |  |  |
|  | 40.4 grams | 1.204 x 1024 atoms |  |
| Iodine |  |  | 0.25 moles |
|  | 100. grams |  | 0.50 moles |

1. 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.*

1. You have half a mole of M & M’s, how many M & M’s do you have?
2. If you have 3.01 x 1023 apples, how many moles of apples do you have?

**Summarizing Your Thoughts**

1. Based on what you thought in question 12, explain why it is difficult to compare chemical quantities using only the mass of samples.
2. Consider the number of hydrogen atoms needed for a mass of 1 gram. How would that compare to the amount of jelly beans you needed to have a mass of 1 gram?
3. What do you think might be the benefit of working in terms of moles when using chemicals?
4. Complete the following:
	1. For **any** element, one mole is equal to its \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ which can be found on the periodic table.
	2. One mole = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles

**Notes on Molar Mass**

**Molar Mass (Formula Weight) Calculations**

Directions: Determine the Molar Mass (the mass of one mole) of each of the compounds below.

**Formula** **Molar Mass**

|  |  |
| --- | --- |
| 1. KMnO4
 |  |
| 1. KCl
 |  |
| 1. Na2SO4
 |  |
| 1. Ca(NO3)2
 |  |
| 1. Al2(SO4)3
 |  |
| 1. (NH4)3PO4
 |  |
| 1. H2CO3
 |  |
| 1. Mg3(PO4)2
 |  |
| 1. Fe2(SO3)3
 |  |

**Notes on Hydrates**

**Hydrates Molar Mass Practice**

|  |  |
| --- | --- |
| 1. Zn3(PO4)2·4H2O
 |  |
| 1. Zn(CH3COO)2·2H2O
 |  |
| 1. Hg2Cr2O7
 |  |
| 1. Ba(ClO3)2
 |  |
| 1. CuSO4·5H2O
 |  |
| 1. NH4C2H3O2
 |  |

What is a Hydrate?

Draw a representation of CuSO4**·**5H2O

**Notes on Mole Road Conversions**

**Mole Road: One-Step Conversions**

Directions: Set up all problems using dimensional analysis (conversion factors). **NO WORK = NO CREDIT!**

1. How many moles is each of the following?

a. 4.81 X 1024 atoms of Li

b. 2.408 x 1024 atoms of aluminum

c. 4.816 x 1022 atoms of hydrogen

d. 6.02 x 1022 molecules Br2

e. 1.5 x 1023 molecules NH3

2. How many atoms are in each of the following?

a. 4.2 moles of manganese

b. 7.5 moles of iodine

3. How many moles is each of the following?

a. 13.95 grams of phosphorous

b. 24 grams of Br2­

c. 68.95 g of gold

d. 160 g of copper

e. 25.6 g of sulfur

4. What is the mass (in grams) of:

a. 1.2 mol of iron?

b. 2.5 moles of platinum

c. 0.3 moles of bromine

d. 2.408 x 1023 atoms of oxygen?

**Mole Road: One-Step and Two-Step Conversions**

Directions: Set up all problems using dimensional analysis (conversion factors). **NO WORK = NO CREDIT!**

1. Find the number of atoms in:
	1. 402 grams of mercury
	2. 204 grams of magnesium
2. Determine the number of moles in each of the quantities below
	1. 25g NaCl
	2. 125g of H2SO4
	3. 100.g of KMnO4
	4. 74g of KCl
	5. 35g of CuSO4·5H2O
3. Determine the number of grams in each of the quantities below.
4. 3.2 x 1023  formula units CuSO4·5H2O
5. 2.81 x 1024 molecules of H2SO4
6. 1.70 x 1022 formula units of KMnO4
7. 3.85 x 1023 formula units of KCl
8. 1.461 x 1023 atoms of Mn

**Mole Practice!**

Directions: Set up all problems using dimensional analysis (conversion factors). **NO WORK = NO CREDIT!**

1. Calculate the formula weights or Molar Masses of the following:

a. H3PO4

b. K2C4H4O6

c. (NH4)3PO4

d. CuSO4 · 5H2O

2. How many **moles** are contained in: **SHOW ALL OF YOUR WORK!**

* 1. 15.56g Al2O3

 b. 4.40 x 10-2g CO2

1. 95.4g C2H6
2. 2.45 g H2SO4
3. 8.00 g H2O2
4. 2.45 g H3PO4
5. 1.25 g Fe2O3
6. 47.5 g F2

3. How many **grams** are contained in: **SHOW ALL OF YOUR WORK!**

a. 0.258 moles Al2O3

b. 4.40 x 10-2 moles SO2

c. 95.4 moles C3H8

d. 0.245 moles H2SO4

e. 0.800 moles CaSO4

f. 2.45 moles H2CO3

g . 1.25 moles Co2O3

i. 50 moles H3PO4

j. 29 moles K2C4H4O6

k. 56 moles (NH4)3PO4

**EVEN Mole Practice!**

Directions: Set up all problems using dimensional analysis (conversion factors). **NO WORK = NO CREDIT!**

1. What is the molar mass of:
	1. H2
	2. Mg(OH)2
	3. CO2
	4. NH4Cl
	5. CuSO4
	6. AgNO3
2. Convert each of the following:
3. How many moles is 12.5 g of magnesium hydroxide?

1. How many moles is 1.46 g of hydrogen gas (H2)?

1. How many grams are in 4.3 moles of ammonium chloride?
2. How many molecules are in 2.0 moles of hydrogen gas (H2)?

1. How many moles is 2.0 x 1025 molecules of silver nitrate?
2. How many atoms of oxygen are in 2.4 x 1023 molecules of copper(II) sulfate?

* 1. How many molecules are in 96 g of carbon dioxide?

* 1. How many oxygen atoms are in 96 g of CO2?

* 1. How many grams would 1.0 x 1025 molecules of copper (II) sulfate weigh?
	2. How much does each individual molecule of copper (II) sulfate weigh?

**Notes on Empirical and Molecular Formulas**

**Empirical and Molecular Formula Practice: SHOW ALL OF YOUR WORK!**

* + 1. Find the **empirical** formula of the following compound from its percent composition.

52.8% Sn, 12.4% Fe, 16.0% C and 18.8% N

Formula: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + 1. Determine the **molecular** formula of the following compound.

54.5% C, 13.6% H and 31.8% N; Molar Mass = 88g

Formula: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + 1. How are the empirical and molecular formulas of a compound related?

**The Strange Case of Mole Airlines Flight 1023**

**Scene of the Crash**At 6:02 a.m. you and your team of medical examiners are called to the scene of a plane crash. You find evidence of a pre-crash explosion. At the site of the explosion a material has been found. Subsequent chemical analysis of the material shows it was:

**C 37.01% H 2.22% N 18.5% O 42.27%**

The mangled passengers are found in and around the crash. They must be identified by the substances found in their belongings or in their bodies, since they are not recognizable and their dental records are not available. Upon further investigation one passenger was suspected of having been murdered before the crash - the time of death was approximated at one hour prior to the crash.

**Your Job:**

**1)** Use the percent composition data in Table 3 to determine formulas for the compounds found with or in the passengers. Do the work on a separate paper and record the empirical formula in the column to the right on table 3. Make sure to show all of your work as it is your work that will be graded. Match these formulas with the identity of each compound listed in Table 1. Be certain to use the number of significant figures in the analysis to determine the number of significant figures you need to use from the periodic table. **For example:** If four significant figures are given in the data, use four significant figures from the periodic table.

**2)** Use the personal data in Table 2 to make a *probable* identification of each passenger.

* Record the identifications on the Victim Identification Form.
* Include the evidence that supports your identification. The solution to the mystery is the one that the evidence points to by logical deduction.
* Determine who was murdered.
* Determine who is *most likely* to have committed the murder.
* Determine the identity of the substance that was found at the site of the explosion.

**Table 1: Possible Compounds Table 2: Personal Data**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |  |
| --- | --- | --- |
| **Identity** | **Formula** | **Notes** |
| Codeine | C18H21NO3 | Pain killer, prescription controlled |
| Cocaine | C17H21NO4 | Narcotic, illegal |
| Aspirin | C9H8O4 | Pain killer |
| Aspartame | C14H18N2O5 | Artificial sweetener |
| Vanilla | C8H8O3 | Flavoring |
| Trinitrotoluene | C7H5N3O6 | Explosive (TNT-dynamite) |
| Nitroglycerine | C3H5N3O9 | Explosive, heart medication |
| Curare | C40H44N4O | Poison |
| Thiobromine | C7H8N4O2 | Chocolate (flavoring) |
| Strychnine | C21H22N2O2 | Rat poison |
| Dimetacrine | C10H13N\* | Prescription drug, antidepressant |
| Acetaminophen | C8H9NO2 | Pain killer (Tylenol) |

 |

|  |  |
| --- | --- |
| **Passengers & Crew** | **Notes** |
| Redd D. Tocroak | Has a heart condition |
| Polly Pillcounter | Pharmacist |
| Hoagie Bunn | Baker |
| Archie Givengrades | Teacher, addicted to sugar free drinks |
| Threwit Allaway | Professional athlete, just suspended for drug violations |
| Ivy Isa Nissue | Environmental engineer, severely depressed |
| Iselle Ubye | Suspected drug dealer |
| Norm Anderson | Suspected leader of a terrorist organization |

 |

**\*the empirical formula rather than the actual formula is**

**used.**

**Table 3: Percent Composition Data of the Compounds Found in or with the Passengers’ Bodies**

|  |  |  |  |
| --- | --- | --- | --- |
| **Passenger** | **Compound Analysis (%)** | **Location** | **Empirical Formula and Substance ID** |
|  | **C** | **H** | **N** | **O** |  |  |
| **1** | 67.31 | 6.98 | 4.62 | 21.10 | Blood |  |
| **2** | 63.15 | 5.30 | -- | 31.55 | Face |  |
| **2** | 46.66 | 4.48 | 31.1 | 17.76 | Stomach |  |
| **3** | 72.15 | 7.08 | 4.68 | 16.03 | Pockets (2000 tablets |  |
| **4** | 15.87 | 2.22 | 18.15 | 63.41 | Blood and Pockets |  |
| **5** | 75.42 | 6.63 | 8.38 | 9.57 | Blood |  |
| **5** | 37.01 | 2.22 | 18.5 | 42.27 | Pockets |  |
| **6** | 57.14 | 6.16 | 9.52 | 27.18 | Pockets |  |
| **7** | 81.19 | 7.51 | 9.39 | 2.68 | Pockets |  |
| **7** | 81.58 | 8.90 | 9.52 | -- | Pockets |  |
| **8** | 60.00 | 4.48 | -- | 35.53 | Pocket |  |
| **8** | 63.56 | 6.00 | 9.27 | 21.17 | Pocket |  |

**Victim Identification Form**

|  |  |  |
| --- | --- | --- |
| **Passenger** | **Most Probable Identity** | **Evidence that Supports Identification** |
| **1** |  |  |
| **2** |  |  |
| **3** |  |  |
| **4** |  |  |
| **5** |  |  |
| **6** |  |  |
| **7** |  |  |
| **8** |  |  |
| **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_was murdered by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_****Identity of Substance at the site of the explosion: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_****Certified by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |

**Solubility Graph Practice**

**Notes on Parts of Solutions and Solubility**



1. What are the two axis of the graph?

1. The curve represents what?
2. Any amount of solute below the line indicates what type of solution?

1. Any amount of solute above the line represents what type of solution?
2. Solutes whose curves move upward are indicating that solubility\_\_\_\_\_\_\_\_\_\_\_ as temperature \_\_\_\_\_\_\_\_\_\_\_.
3. Solutes whose curves move downward indicate that solubility\_\_\_\_\_\_\_\_\_\_ as temperature \_\_\_\_\_\_\_\_\_\_\_\_.

**Solubility Problems to solve**

1. At 10oC, how many grams ofNaNO3 will dissolve in 100 mL of water?
2. What temperature would be required to completely dissolve 100 grams of Sodium Nitrate?
3. If 30 grams of Sodium Chloride dissolved in 100 grams of water at 30 degrees, what type of solution would it be?

**Solubility Practice**

1. Which of the salts shown on the graph is the least soluble in water at 10oC?
2. Which of the salts has the greatest solubility at 10oC?
3. Which of the salts has its solubility affected the least by a change in temperature?
4. How many grams of sodium nitrate must be added to 100 ml to saturate the solution at 50oC?
5. At what temperature do saturated solutions of potassium nitrate and sodium nitrate contain the same weight of solute per 100 mL of water?
6. What two salts have the same degree

of solubility at approximately 19oC?

1. A saturated solution of potassium nitrate is prepared at 60oC using 100.mL of water. How many grams of solute will precipitate out of solution if the temperature is suddenly cooled to 30oC?
2. How many more grams of Potassium Nitrate will dissolve when the temperature of water increases from e temperature range of 60oC to 70oC?
3. If 50. mL of water that is saturated with KClO3 at 25oC is slowly evaporated to dryness, how many grams of the dry salt would be recovered?
4. Thirty grams of KCl are dissolved in 100 mL of water at 45oC. How many additional grams of KCl are needed to make the solution saturated at 80oC?
5. Are the following solutions saturated, unsaturated or supersaturated (assume that all three could form supersaturated solutions)
6. 40. g of KCl in 100 mL of water at 80oC
7. 120. g of KNO3 in 100 mL of water at 60oC
8. 80. g of NaNO3 in 100 mL of water at 10oC

12. Based on the curve of NH3, we can assume that it is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (solid or gas)

**Notes on Concentration (% by Mass and Molarity)**

**Concentration Practice**

Determine the molarity of the following solutions. **SHOW ALL OF YOUR WORK.**

1. Determine the percent composition by mass of a 100 g salt solution that contains 20 g of salt.
2. Calculate the mass of solvent in grams in a solution containing 3.0 grams of Tylenol if the mass percent is 3.5%.
3. 0.50 moles of sodium chloride is dissolved to make 0.75 liters of solution.
4. 0.50 grams of sodium chloride is dissolved to make 0.075 liters of solution.

**Molarity Practice**

1. 0.50 grams of sodium chloride is dissolved to make 0.075 mL of solution.
2. 734 grams of lithium sulfate are dissolved to make 875 mL of solution.
3. 6.7 x 10-2 grams of Pb(C2H3O2)4 are dissolved to make 3.5 mL of solution.
4. I have two solutions. In the first solution, 1.0 moles of sodium chloride is dissolved to make 1.0 liters of solution. In the second one, 1.0 moles of sodium chloride is added to 1.0 liters of water. Is the molarity of each solution the same? Explain your answer.
5. How many grams of potassium carbonate are needed to make 200 mL of a 2.5 M solution?
6. How many liters of 4 M solution can be made using 100 grams of lithium bromide?
7. What is the concentration of a 450 mL solution that contains 200 grams of iron (II) chloride?
8. How many grams of ammonium sulfate are needed to make a 0.25 M solution with 2.5 L
9. What is the concentration of a solution that has a volume of 2.5 L and contains 660 grams of calcium phosphate?
10. How many grams of copper (II) fluoride are needed to make 6.7 liters of a 1.2 M solution?
11. How many liters of 0.88 M solution can be made with 25.5 grams of lithium fluoride?
12. What is the concentration of a solution that with a volume of 660 ml that contains 33.4 grams of aluminum acetate?

**Dilutions Practice**

**Notes on Dilutions**

1. If I add 25 mL of water to 125 mL of a 0.15 M NaOH solution, what will the molarity of the diluted solution be?
2. If I add water to 100.0 mL of a 0.15 M NaOH solution until the final volume is 150 mL, what will the molarity of the diluted solution be?
3. How much 0.05 M HCl solution can be made by diluting 250 mL of 10 M HCl?
4. I have 345 mL of a 1.5 M NaCl solution. If I boil the water until the volume of the solution is 250 mL, what will the molarity of the solution be?

**Unit 8 Review: Moles and Solutions**

Find the molar mass of:

1. CH4 2. Ca(NO3)2 3. iron(II) oxide

4. How many moles are in 75.1g of FeO?

5. How many grams are in 2.5 moles of CH4?

6. a. How many molecules of Ca(NO3)2 in 10.9 moles?

 b. How many oxygen atoms are there?

7. How many grams of FeO are in 1.96 x 1024 molecules?

8. How many molecules are in 72.6g of CH4?

9.What is the molarity of a 50.0mL solution that contains 29.04g NaCl?

10. Narcotics agents confiscated an unknown substance that was suspected to be methaqualone. Its molecular formula is C16H14N2O. Analysis found the sample to have 77% carbon, 5.5% hydrogen, 15.3% nitrogen, and the rest oxygen. Was it methaqualone?

11. What mass of CO2 has the same number of molecules as 192g of H2O?

12. A gas containing carbon and oxygen is decomposed and is found to contain 0.36g of carbon and 0.48g of oxygen. What is the empirical formula of this gas?

14. The empirical formula of a compound is CH2O2. The actual molar mass of this compound is 184g. What is the molecular formula of the compound?

15. A 31.0g sample of rust (an iron oxide) is composed of 21.7g of iron. Determine the empirical formula of this rust and give the correct chemical name.

16. Caffeine contains 49.98% C, 5.15% H, 28.87% N, and 16.49% O, and has a molar mass of 194.2 g/mol. What is its molecular formula?

Answer Key: 1. **16.0 g/mol** 2. **164.1 g/mol** 3. **71.8 g/mol** 4. **1.05 moles** 5. **40.g** 6a. **6.56 x 1024 molecules**

6b. **3.94 x 1025 atoms O** 7. **234g** 8. **2.73 x 1024** 9. **9.94M** 10. **No** 11. **469g** 12. **CO**

13. **17.5g Mg(OH)2** 14. **C4H8O8** 15. **empirical = Fe2O3 name = iron(III) oxide** 16. **C8H10N4O2**

