Lab 14. Molar Relationships: What Are the Identities of the Unknown Compounds?

Introduction

The concept of the mole is important for understanding chemistry. The mole provides a measure of the number of atoms present in a sample of a compound. One mole of an element or compound contains 6.02×10^{23} atoms or molecules. This quantity is referred to as the Avogadro constant. Knowing the amounts of particles allows chemists to understand how different chemicals behave during chemical reactions and predict the outcomes of reactions. Moles provide a standardized way of comparing elements. Using the Avogadro constant, chemists can use other measures, such as mass or volume, to determine the amount of particles a sample has.

To use mass to determine the number of moles of an element or molecule in a sample, you must also know the molar mass of that element or molecule. The molar mass refers to the total mass of an element present in one mole of that element. The unit for these masses is grams per mole (g/mol). The molar mass of an element is easily identified on most periodic tables, where it is typically listed in the box provided for a particular element. Examples of molar mass include carbon (C), 12.011 g/mol; oxygen (O), 15.994 g/mol; and gold (Au), 196.967 g/mol. To determine the molar mass for a compound made of larger molecules, you must add up the molar masses of all the atoms present in the molecular formula. For example, the molar mass of CO_2 is 43.999 g/mol, which is calculated by 12.011 g/mol (C) + 15.994 g/mol (O) + 15.994 g/mol (O). Remember that you have to include the total number of atoms in the molecular formula when calculating molar mass, so be mindful of the subscripts in those formulas.

By knowing the molar mass of a compound and the mass of a sample of that compound, you can determine the number of moles in the compound. Continuing from the example above, if you have a sample of CO_2 whose mass is 2.523 g, then you can determine the number of moles in that sample by dividing the actual mass by the molar mass (e.g., 2.523 g / 43.999 g/mol = 0.0573 moles of CO_2).

You will now use your understanding of the relationships between moles, molar mass, and mass of a sample to identify some unknown compounds. Remember, moles provide a standardized unit of measure (based on the Avogadro constant) so that chemists can compare a wide variety of substances, including the amount of substances needed and produced by a chemical reaction.

Your Task

You will be given seven sealed bags. Each bag will be filled with a different powder and will be labeled with the number of moles of powder that is inside the bag. Your task will be to identify the powder in each bag. The unidentified powders could be any of the following compounds:

- Calcium acetate, $Ca(C_2H_3O_2)_2$
- Calcium oxide, CaO
- Potassium sulfate, K_2SO_4
- Sodium acetate, $NaC_2H_3O_2$
- Sodium carbonate, Na_2CO_3
- Sodium chloride, NaCl
- Zinc(II) oxide, ZnO

The guiding question of this investigation is, **What are the identities of the unknown compounds?**

Materials

You may use any of the following materials during your investigation:

Consumables	**Equipment**
• Sealed plastic bags of unknown compounds • Empty plastic bags	• Electronic or triple beam balance • Periodic table

Safety Precautions

Follow all normal lab safety rules. Your teacher will explain relevant and important information about working with the chemicals associated with this investigation. In addition, take the following safety precautions:

- Wear indirectly vented chemical-splash goggles while in the laboratory.
- Wash your hands with soap and water before leaving the laboratory.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to design and conduct an investigation. To accomplish this task, you must first determine what type of data you need to collect, how you will collect the data, and how you will analyze the data.

To determine *what type of data you need to collect*, think about what type of measurements you will need to make during your investigation.

To determine *how you will collect the data*, think about the following questions:

- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect and how will you organize it?

To determine *how you will analyze the data*, think about the following questions:

- What type of table or graph could you create to help make sense of your data?
- What types of calculations will you need to make?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

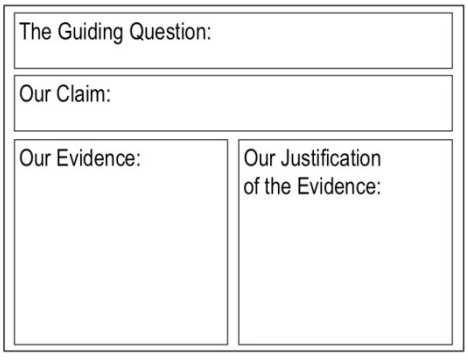
- the importance of identifying patterns,
- which proportional relationships are critical to the understanding of this investigation,
- how scientific knowledge changes over time in light of new evidence, and
- the difference between data and evidence.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a *claim*, which is your answer to the guiding question. Your argument must also include *evidence* in support of your claim. The evidence is your analysis of the data and your interpretation of what the analysis means. Finally, you must include a *justification* of the evidence in your argument. You will therefore need to use a scientific concept or principle to explain why the evidence that you decided to use is relevant and important. You will create your initial argument on a whiteboard. Your whiteboard must include all the information shown in Figure L14.1.

FIGURE L14.1

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group stays at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the initial arguments so these mistakes can be

fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. To critique an argument, you might need more information than what is included on the whiteboard. You might therefore need to ask the presenter one or more follow-up questions, such as:

- How did your group collect the data? Why did you use that method?
- What did your group do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- What did your group do to analyze the data? Did you check your calculations?
- Is that the only way to interpret the results of your group's analysis? How do you know that your interpretation of the analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before deciding on that one? Why did you abandon those alternative ideas?
- How confident are you that your group's claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!