Honors Chemistry Lab 9: Introduction to the Mole 

A mole is simply a unit of measurement. Units are invented when existing units are inadequate. Chemical reactions often take place at levels where using grams wouldn't make sense, yet using absolute numbers of atoms/ molecules/ions would be confusing, too. Like all units, a mole has to be based on something reproducible. A mole is the quantity of anything that has the same number of particles found in 12.000 grams of carbon-12. That number of particles is Avogadro's number, which is roughly 6.022×10^{23}, or written out, 602,200,000,000,000,000,000,000 atoms. A mole of carbon atoms is 6.022×10^{23} carbon atoms. A mole of chemistry teachers is 6.022×10^{23} chemistry teachers. If you look up an element's atomic mass and "weigh out" that number of grams of that substance, you will have 6.022×10^{23} atoms of that element. The purpose of this lab is to understand the basic concept of a mole and to model the practice of counting by weighing. Please note that there are two parts to this lab and they may be completed in any order to finish this investigation as expeditiously as possible.

Part 1: Mole Set (obtain a mole set that contains four element specimens)

Q1. Examine the four specimens and record detailed qualitative data for each. Note that they are stamped "A" through "D" to help you distinguish between the samples. Also note that each sample contains exactly 1 mole.

Q2. Different kinds of atoms have different masses. How can you tell that this is true from your observations thus far? Did you need to make use of the fact that each sample contained one mole of atoms? Which of the four samples is made of atoms with the least mass?

Q3. Since each sample contains the same number of atoms, a glance will tell you that atoms of different elements are not all the same size. List the four samples in order according to the size of their atoms. Are there any assumptions that you needed to answer this question? Are there any samples whose atoms seem to be the same size and if so, which?

Q4. Sample "B" is noticeably less dense than the other samples in the set. In terms of the atoms the samples are made of, what are two reasons that sample "B" is the least dense? Are there any assumptions that you needed to answer this question?

Q5. Now use a metric ruler, a balance, your podcast notes and other tools or resources provided to determine the identity of the four elements in your set. Even if you believe you can determine the elements by sight, you are required to provide quantitative data and a rationale based on the fact that each sample contains one mole of some element to support and corroborate your answer.

Before attempting the following questions, be sure that you have correctly identified the four elements. You will need to obtain my initials to continue beyond this point.

Initials
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Q6. Calculate the mass of an aluminum atom. Show all calculations and state any assumptions that were made and make sure to follow the rules for significant figures. Now complete this calculation for the remaining three samples.

Q7. Calculate the volume of an aluminum atom. In order to answer this question, it is acceptable, and necessary, to make an assumption about the shape of an atom. Although atoms are complex in shape, it is common to assume they are spherical. For this problem you will need to assume that atoms are cube shaped. Because of this assumption, your answer will merely be a good approximation. Follow the rules for significant figures.

Q8. Assume that atoms are cube-shaped. The volume of each is the third power of the length of an edge of the cube. Likewise, the length of the edge of a cube is the one-third power (also called the cube root) of the volume. If we instead imagine atoms being spheres packed together in a cubic arrangement, then we can assume the diameter of the sphere to be identical to this length value. Chemists often make the simplifying assumption that atoms are spherical, and speak of “atomic radius”. Assume this, and now assume that the atoms in each case are packed in a cubic arrangement. Calculate the diameter of each of the four kinds of atoms in this set. Then calculate the radius for each kind of atom. Compare your experimental value with the “true” or theoretical values. In order to quantify discrepancies between these two values, you will additionally need to calculate the percentage error (% difference) for each sample. Lastly, calculate the deviation for each of the samples. You may choose to create a data table and you must show all work.

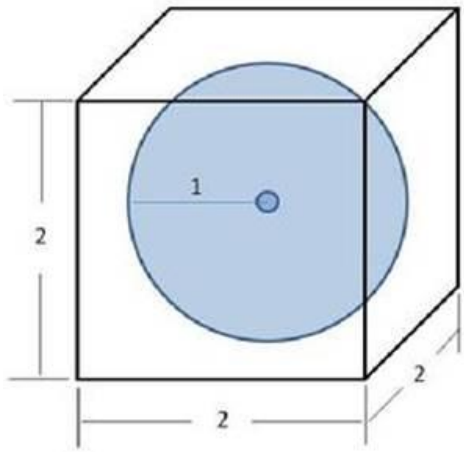
$$\text{Arithmetic mean} = \frac{\Sigma \text{ data points}}{\text{number of data points (n)}}$$

$$\text{Error} = \text{Experimental value} - \text{"true" or theoretical value}$$

$$\text{Percent Error} = \frac{|\text{Error}|}{\text{Theoretical value}} \bullet 100$$

$$\text{Deviation} = |\text{Experimental value} - \text{arithmetic mean}|$$

$$\text{Percent Deviation} = \frac{\text{Deviation}}{\text{Theoretical value}} \bullet 100$$



Part 2: Counting by Weight (Read steps 1-6 and create a data table suitable for your anticipated data set)

1). Determine the average mass of a penny by weighing 25 pennies and dividing the total mass by the number of pennies. **2)**. Repeat step 1 two more times with different pennies, and take the average of your three results. **3)**. Weigh about three-fourths of you total number of pennies. **4)**. Calculate how many pennies you weighed. **5)**. Count the number of pennies in your sample and compare that to the number you calculated in steps 3 & 4. **6)**. Repeat steps 3, 4 and 5 with a different sample size.

Questions:

Q9. Did the number of pennies you counted in the sample (step five) equal the number you calculated by weighing (step four)? If there was not agreement, propose an explanation.

Q10. Explain how you would use the balance to “count out” 185 pennies.

Q11. What is the advantage of using a larger sample size in step 1? What is a disadvantage?

Q12. How are the pennies like atoms in this experiment? Justify your response.