Title: Understanding the Mole and Molar Mass Concepts

Description of Lesson: The Mole concept is fundamental to the understanding the world of atoms, molecules, and compounds. Its quantitative aspects in terms of humongous numbers of minute particles and their corresponding mass baffle a lot of students. Without a concrete understanding of the mole, students are just manipulating numbers in converting from moles to molar mass and vice versa. This lesson attempts to help students grasp the two-fold number and mass concept of the mole.

Length of Lesson: 1 block lesson 1 hour and 30 minutes

Student Objectives:
1. Students will understand the number concept of the Mole.
2. Student will demonstrate their understanding of the Mole number concept by the ability to convert Moles to numbers and numbers to Moles of familiar objects and elements using dimensional analysis.
3. Students will understand the mass concept of the Mole of Molar Mass
4. Students will demonstrate their understanding of Molar Mass by the ability to convert Moles of substances to grams and vice versa.
5. Students will understand the difference between gram-atomic mass and gram-molecular mass.

Materials:
For the teacher:
1. Create Process Oriented Guided Inquiry Learning (POGIL) worksheets on the Mole and Molar Mass concepts
2. Make copies of the POGIL worksheets for all classes taught.

For each group: 4 POGIL worksheets per group, each group member furnished with a laminated role card, outlining each person’s responsibilities in the group discussion.
For the class: 24 copies per class
Procedure:

Step 1: Arrange class into groups of 4 students with mixed ability levels.
Step 2: Assign jobs to each student in the groups. The spokesperson for each group gets a special name tag.
Step 3: Distribute POGIL copies of worksheets and observe student interactions.
Step 4: Answer questions and provide pointers if some groups could not continue or could not agree on the correct response to questions posed in the worksheet.
Step 5: Have each group’s spokesperson report on their findings.
Step 6: Wrap up discussion and summarize concepts learned.

Assessment: Collect the answers written by the groups’ recorders and check for understanding. Give feedback by grading the papers submitted. Allow incorrect responses to be reworked to enhance comprehension or correct misconception of concepts to be learned.

Kansas Standards Addressed:
Standard 1: Science as Inquiry
Benchmark 1: The student will demonstrate abilities necessary to do the processes of scientific inquiry.
Indicator 4: The student engages in conducting an inquiry, formulating and revising his or her scientific explanations and models (physical, conceptual, or mathematical) using logic and evidence, and recognizing that potential alternative explanations and models should be considered.
Indicator 5: The student engages in communicating and defending the design, results and conclusion of his/her investigation.
The Mole and Molar Mass

The Mole
The dozen is a unit of counting objects.
1. How many eggs are there in a dozen eggs?

2. How many pencils are in a dozen pencils?

3. Write two forms of the conversion factor that will help convert a dozen to number of objects and number of objects to dozen.

4. Using the appropriate conversion factor in #2, convert 3.75 dozen eggs to number of eggs.

5. Using the appropriate conversion factor in #2, convert 248 eggs into dozens of eggs.

6. Similarly, the **mole** (mol) is a unit for counting objects. It is especially useful for counting tiny objects like atoms, molecules, ions, and formula-units.

   \[ 1 \text{ mole of objects} = 6.022 \times 10^{23} \text{ objects} \]

7. How many atoms of copper are in 1 mole of copper?

8. How many molecules of water are in 1 mole of water?

9. Write two forms of the conversion factor that will convert one mole to number of objects and number of objects to moles.
10. Using the appropriate conversion factor in # 8, how many atoms of zinc are in 10.2 moles of zinc?

11. Using the appropriate conversion factor in # 8, find out how many moles of water contain $1.51 \times 10^{24}$ molecules of water.

**Fun Questions:**
12. A grocery store has 75 dozen packages of hot dogs in stock. If there are 10 hot dogs in each package, how many moles of hot dogs is this?

13. Estimate the number of times a human heart beats during a life time of 80 years. Express this number in moles.

**Molar Mass**
Atoms and molecules are extremely small particles. Scientists have developed a method of measuring the mass of an atom relative to the mass of a chosen standard atom. This standard atom is the carbon-12 atom. The carbon-12 atom has been assigned a mass of exactly 12 amu(s).

1. What does amu stand for?

2. How is amu defined?

3. What would 1 amu be in grams if measured on a chemical balance?

Using the information given below, answer the following questions.

<table>
<thead>
<tr>
<th>Hydrogen</th>
<th>Carbon</th>
<th>Sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>H</td>
<td>C</td>
<td>Na</td>
</tr>
<tr>
<td>1.00794</td>
<td>12.011</td>
<td>22.989</td>
</tr>
</tbody>
</table>
4. Given that 1 amu = $1.6606 \times 10^{-24}$ g, what is the mass of one mole of hydrogen atoms?

5. What is the unit given to your calculation?

**Wait a minute. You have just calculated the molar mass of hydrogen!**

6. What is the molar mass of carbon? (Do not forget the unit!)

7. What is the molar mass of sodium?

8. What is the relationship between molar mass in grams per mole (g/mol) and average atomic mass in amu of each element?

9. Using what you have learned so far, fill the blanks in the boxes below.

| Molar mass of Pb = | Molar mass of Si = | Molar mass of Cl = |

10. The molar mass of elements that exist as atoms can also be called **gram-atomic mass**. What is the name given to the molar masses of substances that exist as molecules?

11. How are the molar masses of molecules determined?

12. Calculate the molar mass of water molecules.

13. What is the gram-molecular mass of sulfur dioxide?

14. What is the gram-molecular mass of ammonia (NH$_3$)?