Name ______________

Counting by Weighing

When a chemical reaction takes place, individual atoms and molecules collide and combine or recombine to form new substances. Atoms and molecules are so small that you cannot see them easily, nor can you measure their diameter with a meter stick or measure their mass with a balance. Yet, chemists need to keep track of the number of atoms and molecules, or at least the relationship between the number of atoms and molecules in a chemical reaction. What method has been devised to count the many billions of atoms that are involved in a chemical reaction? Let's find out.

Record all required information and calculations on this handout . Be sure to include units. This entire assignment is due at the beginning of class tomorrow.

1. Select 20 **small** paper clips. Measure their mass on the balance. Record this mass. **Calculate** the average mass of 1 paper clip.

Mass of 20 paper clips___________

Average mass of 1 paper clip _________

WORK:

2. **Calculate** the mass of 100 **small** paper clips. Then add **small** paper clips to the balance until you have a sample, which is approximately equal to this mass you just calculated. Count the paper clips you just massed. Record the number of paper clips.

Predicted mass of 100 paper clips ______________

WORK:

Actual number of paper clips ____________

3. In the space below- describe a method to obtain 1000 **small** paper clips **without counting** them.

4. **Calculate** the expected mass of 12,000 **small** paper clips -**Show your work.**

5. Obtain a sealed envelope of **small** paper clips. A code number and the mass of the empty envelope is written on the sealed envelop. Determine the number of small paper clips in the envelop-**without opening it, of course.**

Code #_____ Mass of envelop_________

Predicted number of small paper clips_____

WORK:

8. Describe how you would use this method to determine how many atoms or molecules you have in a given sample. What information would you need to know about the atom or molecule to complete this task?

9. Chemists actually do count by weighing. Look at the labeled bags on the teacher's desk. List the substances and their masses in the space below.

10. Which does there seem to be the most of? The least?

Actually they all contain the same amount, well at least the same number of **particles**.

11. **Explain why they could have the same number of particles, but different masses and volumes.**

The bags on the teacher's desk all contain 1 **mole** of the various substances. The mass number on the periodic table tells us what 1 mole of any substance would have a mass of in grams.

What is the mass of 1 mole of Carbon? Helium? Uranium?
Molar mass of Carbon_____
Molar mass of Helium _______
Molar mass of Uranium _______

STAY TUNED FOR MORE ABOUT THE MOLE

WHAT ABOUT COUNTING ATOMS?

Because atoms are so tiny, the normal units of mass – the gram and the kilogram – are much too large to be convenient. For example, the mass of a single carbon atom is 1.99×10^{-23} g. To avoid using these terms, scientists have defined a much smaller unit of mass called the **atomic mass unit**, which is abbreviated **amu**:

$$\text{A amu} = 1.66 \times 10^{-24}\ \text{g}$$

To count atoms, we need to know the average mass of individual atoms – just like you found for the paper clips – we call this the **average atomic mass**. For a carbon atom, the average atomic mass is 12.01 amu. Scientists have already figured out the average atomic masses of all the elements – they are conveniently located on the Periodic Table! Now that we know the average mass of the carbon atom, we can count carbon atoms by weighing samples of natural carbon. For example, what mass of natural carbon must we take to have 1000 carbon atoms present? Because 12.01 amu is the average mass,

$$\text{Mass of 1000 natural carbon atoms} = (1000\ \text{atoms})\left(12.01\ \frac{\text{amu}}{\text{Atom}}\right)$$
$$= 12{,}010\ \text{amu} = 12.01 \times 10^{3}\ \text{amu}$$

Let's try another example: A sample of carbon weighs 3.00×10^{20} amu, how many carbon atoms are present in this sample?

$$3.00 \times 10^{20}\ \text{amu} \times \frac{1\ \text{carbon atom}}{12.01\ \text{amu}} = 2.50 \times 10^{19}\ \text{carbon atoms}$$

Complete the following problems: **SHOW ALL WORK!**

1. Calculate the mass of a sample that contains 23 nitrogen atoms.

2. Calculate the number of sodium atoms present in a sample that has a mass of 1172.49 amu

3. Calculate the number of oxygen atoms in a sample that has a mass of 288 amu.

4. Calculate the mass, in amu, of each of the following samples:
   a. 278 atoms of Li

   b. 1 million C atoms

   c. 5×10^{25} sodium atoms

   d. 1 atom of cadmium

   e. 6.022×10^{23} atoms of mercury

5. Calculate the number of atoms present in each of the following samples.
   a. 52.00 amu of chromium

   b. 749.2 amu of arsenic

   c. 4274 amu of rubidium

   d. 2698 amu of aluminum

6. What does an average magnesium atom weigh (in amu)?

   a. What would 345 magnesium atoms weigh?

   b. How many magnesium atoms are contained in a sample of magnesium that has a mass of 2.071×10^4 amu?

7. What does an average iodine atom weigh (in amu)?

   a. How many atoms of iodine are contained in a sample of iodine that has a mass of 7.043×10^4 amu?

   b. What would 451 iodine atoms weigh?