Key

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 12.01 amu
Molar mass of Helium 4.003 amu
Molar mass of Uranium 238.0 amu

**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 $1.99 \times 10^{-23}$ 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 $3.00 \times 10^{20}$ 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.

$$23\text{ N atoms} \times \frac{1\text{ mol N}}{6.022 \times 10^{23}\text{ N atoms}} \times \frac{14.01\text{ g N}}{1\text{ mol N}} = \boxed{5.351 \times 10^{-22}\text{ g N}}$$

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

$$1172.49\text{ amu} \times \frac{1\text{ Na atom}}{22.99\text{ amu}} = \boxed{51\text{ Na atoms}}$$

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

$288 \text{ amu } O \times \frac{1 \text{ O atom}}{16.00 \text{ amu } O} = \boxed{18 \text{ O atoms}}$

4. Calculate the mass, in amu, of each of the following samples:
   a. 278 atoms of Li $278 \text{ atoms} \times \frac{6.941 \text{ amu Li}}{1 \text{ atom Li}} = \boxed{1930. \text{ amu}}$
   b. 1 million C atoms $1 \text{ million C atoms} \times \frac{12.01 \text{ amu}}{1 \text{ C atom}} = \boxed{12{,}010{,}000 \text{ amu}}$
   c. $5 \times 10^{25}$ sodium atoms $5 \times 10^{25} \text{ Na atoms} \times \frac{22.99 \text{ amu}}{1 \text{ Na atom}} = \boxed{1.150 \times 10^{27} \text{ amu}}$
   d. 1 atom of cadmium $\boxed{= 112.4 \text{ amu}}$
   e. $6.022 \times 10^{23}$ atoms of mercury

   $6.022 \times 10^{23} \text{ atom Hg} \times \frac{200.6 \text{ amu}}{1 \text{ atom Hg}} = \boxed{1.208 \times 10^{26} \text{ amu}}$

5. Calculate the number of atoms present in each of the following samples.
   a. 52.00 amu of chromium $\boxed{1 \text{ atom Cr}}$
   b. 749.2 amu of arsenic $749.2 \text{ amu} \times \frac{1 \text{ atom As}}{74.92 \text{ amu As}} = \boxed{10 \text{ atoms}}$
   c. 4274 amu of rubidium $4274 \text{ amu} \times \frac{1 \text{ atom Rb}}{85.47 \text{ amu Rb}} = \boxed{50 \text{ atoms Rb}}$
   d. 2698 amu of aluminum $2698 \text{ amu} \times \frac{1 \text{ atom Al}}{26.98 \text{ amu Al}} = \boxed{100 \text{ atoms Al}}$

6. What does an average magnesium atom weigh (in amu)? $\boxed{24.31 \text{ amu}}$
   a. What would 345 magnesium atoms weigh?

   $345 \text{ Mg atoms} \times 24.31 \text{ amu} / 1 \text{ Mg atom} = \boxed{8387 \text{ amu}}$
   b. How many magnesium atoms are contained in a sample of magnesium that has a mass of $2.071 \times 10^4$ amu?

   $2.071 \times 10^4 \text{ amu} \times \frac{1 \text{ Mg atom}}{24.31 \text{ amu}} = \boxed{852 \text{ atoms}}$

7. What does an average iodine atom weigh (in amu)? $\boxed{126.9 \text{ amu}}$
   a. How many atoms of iodine are contained in a sample of iodine that has a mass of $7.043 \times 10^4$ amu? $7.043 \times 10^4 \text{ amu} \times \frac{1 \text{ I atom}}{126.9 \text{ amu}} = \boxed{555 \text{ atoms}}$
   b. What would 451 iodine atoms weigh?

   $451 \text{ I atoms} \times \frac{126.9 \text{ amu I}}{1 \text{ I atom}} = \boxed{57230 \text{ amu}}$