The Mole, Molar Mass, and Elemental Composition Worksheet

1. The molecular formula of allicin, the compound responsible for the characteristic smell of garlic, is $C_6H_{10}OS_2$.
    a. What is the molar mass of allicin?

$$6(12.01) + 10(1.008) + 16.00 + 2(32.07) = 162.28 \frac{\text{g}}{\text{mol}}\ C_6H_{10}OS_2$$

    b. How many moles of allicin are present in 5.00 mg of this substance?

$$5.00\ \text{mg}\ C_6H_{10}OS_2 \left(\frac{1\ \text{g}\ C_6H_{10}OS_2}{1000\ \text{mg}\ C_6H_{10}OS_2}\right)\left(\frac{1\ \text{mol}\ C_6H_{10}OS_2}{162.28\ \text{g}\ C_6H_{10}OS_2}\right)$$
$$= 3.08 \times 10^{-5}\ \text{mol}\ C_6H_{10}OS_2$$

    c. How many molecules of allicin are in 5.00 mg of this substance?

$$3.08 \times 10^{-5}\ \text{mol}\ C_6H_{10}OS_2 \left(\frac{6.022 \times 10^{23}\ \text{molec}\ C_6H_{10}OS_2}{1\ \text{mol}\ C_6H_{10}OS_2}\right)$$
$$= 1.85 \times 10^{19}\ \text{molec}\ C_6H_{10}OS_2$$

    d. How many S atoms are present in 5.00 mg of allicin?

$$1.85 \times 10^{19}\ \text{molec}\ C_6H_{10}OS_2 \left(\frac{2\ \text{atoms S}}{1\ \text{molec}\ C_6H_{10}OS_2}\right) = 3.70 \times 10^{19}\ \text{atoms S}$$

2. The molecular formula of aspartame, the artificial sweetener marketed as NutraSweet®, is $C_{14}H_{18}N_2O_5$.
    a. What is the molar mass of aspartame?

$$14(12.01) + 18(1.008) + 2(14.01) + 5(16.00) = 294.30 \frac{\text{g}}{\text{mol}}\ C_{14}H_{18}N_2O_5$$

    b. How many moles of aspartame are present in 1.00 mg of aspartame?

$$1.00\ \text{mg}\ C_{14}H_{18}N_2O_5 \left(\frac{1\ \text{g}\ C_{14}H_{18}N_2O_5}{1000\ \text{mg}\ C_{14}H_{18}N_2O_5}\right)\left(\frac{1\ \text{mol}\ C_{14}H_{18}N_2O_5}{294.30\ \text{g}\ C_{14}H_{18}N_2O_5}\right)$$
$$= 3.40 \times 10^{-6}\ \text{mol}\ C_{14}H_{18}N_2O_5$$

    c. How many molecules of aspartame are in 1.00 mg of aspartame?

$$3.40 \times 10^{-6}\ \text{mol}\ C_{14}H_{18}N_2O_5 \left(\frac{6.022 \times 10^{23}\ \text{molec}\ C_{14}H_{18}N_2O_5}{1\ \text{mol}\ C_{14}H_{18}N_2O_5}\right)$$
$$= 2.05 \times 10^{18}\ \text{molec}\ C_{14}H_{18}N_2O_5$$

    d. How many hydrogen atoms are present in 1.00 mg of aspartame?

$$2.05 \times 10^{18}\ \text{molec}\ C_{14}H_{18}N_2O_5 \left(\frac{18\ \text{atoms H}}{1\ \text{molec}\ C_{14}H_{18}N_2O_5}\right) = 3.69 \times 10^{19}\ \text{atoms H}$$

3. A solution of glucose, $C_6H_{12}O_6$, contains 1.250×10^{21} carbon atoms.

   a. How many atoms of hydrogen does it contain?

$$1.250 \times 10^{21} \text{ atoms C} \left(\frac{12 \text{ atoms H}}{6 \text{ atoms C}}\right) = 2.500 \times 10^{21} \text{ atoms H}$$

   b. How many molecules of glucose does it contain?

$$1.250 \times 10^{21} \text{atoms C} = \left(\frac{1 \text{ molec } C_6H_{12}O_6}{6 \text{ atom C}}\right) = 2.083 \times 10^{20} \text{ molec } C_6H_{12}O_6$$

   c. How many moles of glucose does it contain?

$$2.083 \times 10^{20} \text{ molec } C_6H_{12}O_6 \left(\frac{1 \text{ mol } C_6H_{12}O_6}{6.022 \times 10^{23} \text{ molec } C_6H_{12}O_6}\right)$$

$$= 3.459 \times 10^{-4} \text{ mol } C_6H_{12}O_6$$

   d. What is the mass of this sample in grams?

$$3.459 \times 10^{-4} \text{ mol } C_6H_{12}O_6 \left(\frac{180.16 \text{ g } C_6H_{12}O_6}{1 \text{ mol } C_6H_{12}O_6}\right) = 0.06232 \text{ g } C_6H_{12}O_6$$

   e. If the density of the solution is 32 g/L, how many liters is the solution?

$$0.06232 \text{ g } C_6H_{12}O_6 \left(\frac{1 \text{ L sol'n}}{32 \text{ g } C_6H_{12}O_6}\right) = 0.0019 \text{ L sol'n}$$

4. A solution of the hormone testosterone, $C_{19}H_{28}O_2$, contains 3.88×10^{21} hydrogen atoms.

   a. How many atoms of carbon does it contain?

$$3.88 \times 10^{21} \text{ atoms H} \left(\frac{19 \text{ atoms C}}{28 \text{ atoms H}}\right) = 2.63 \times 10^{21} \text{ atoms C}$$

   b. How many molecules of testosterone does it contain?

$$3.88 \times 10^{21} \text{ atoms H} = \left(\frac{1 \text{ molec } C_{19}H_{28}O_2}{28 \text{ atom H}}\right) = 1.39 \times 10^{20} \text{ molec } C_{19}H_{28}O_2$$

   c. How many moles of testosterone does it contain?

$$1.39 \times 10^{20} \text{ molec } C_{19}H_{28}O_2 \left(\frac{1 \text{ mol } C_{19}H_{28}O_2}{6.022 \times 10^{23} \text{ molec } C_{19}H_{28}O_2}\right)$$

$$= 2.31 \times 10^{-4} \text{ mol } C_{19}H_{28}O_2$$

   d. What is the mass of this sample in grams?

$$2.31 \times 10^{-4} \text{ mol } C_{19}H_{28}O_2 \left(\frac{288.41 \text{ g } C_{19}H_{28}O_2}{1 \text{ mol } C_{19}H_{28}O_2}\right) = 0.0666 \text{ g } C_{19}H_{28}O_2$$

   e. If the density of the solution is 0.00142 g/mL, how many mL is the solution?

$$0.0666 \text{ g } C_{19}H_{28}O_2 \left(\frac{1 \text{ mL sol'n}}{0.00142 \text{ g } C_{19}H_{28}O_2}\right) = 46.9 \text{ mL sol'n}$$

5. The allowable mass of vinyl chloride, C_2H_3Cl, in the atmosphere in a chemical plant is 2.0×10^{-6} g. How many molecules of vinyl chloride does this represent?

$$2.0 \times 10^{-6}\ \text{g}\ C_2H_3Cl\left(\frac{1\ \text{mol}\ C_2H_3Cl}{62.47\ \text{g}\ C_2H_3Cl}\right)\left(\frac{6.022 \times 10^{23}\ \text{molec}\ C_2H_3Cl}{1\ \text{mol}\ C_2H_3Cl}\right)$$
$$= 1.9 \times 10^{16}\text{molec}\ C_2H_3Cl$$

6. At least 25 μg of tetrahydrocannabinol (THC), the active ingredient in marijuana, is required to produce intoxication. The molecular formula of THC is $C_{21}H_{30}O_2$. How many carbon atoms are in 25 μg of THC?

$$25\ \mu\text{g}\ C_{21}H_{30}O_2\left(\frac{1\ \text{g}\ C_{21}H_{30}O_2}{10^6\ \mu\text{g}\ C_{21}H_{30}O_2}\right)\left(\frac{1\ \text{mol}\ C_{21}H_{30}O_2}{314.45\ \text{g}\ C_{21}H_{30}O_2}\right)\left(\frac{6.022 \times 10^{23}\ \text{molec}\ C_{21}H_{30}O_2}{1\ \text{mol}\ C_{21}H_{30}O_2}\right)\left(\frac{21\ \text{atoms C}}{1\ \text{molec}\ C_{21}H_{30}O_2}\right)$$
$$= 1.0 \times 10^{18}\ \text{atoms C}$$

7. The molecular formula of acetylsalicylic acid (aspirin), one of the most common pain relievers, is $C_9H_8O_4$. If a 80.0 mL solution of aspirin in water has a density of 0.075 g/mL, how many molecules of aspirin are in the 80.0 mL solution?

$$80.0\ \text{mL sol'n}\left(\frac{0.075\ \text{g}\ C_9H_8O_4}{1\ \text{mL sol'n}}\right)\left(\frac{1\ \text{mol}\ C_9H_8O_4}{180.15\ \text{g}\ C_9H_8O_4}\right)\left(\frac{6.022 \times 10^{23}\ \text{molec}\ C_9H_8O_4}{1\ \text{mol}\ C_9H_8O_4}\right)$$
$$= 2.0 \times 10^{22}\ \text{molec}\ C_9H_8O_4$$