

### 3.5 Review Questions

1. Menthol is a strong-smelling compound that is used in cough drops. It has a formula of  $C_{10}H_{20}O$ . Calculate its percentage composition.

In one mole  $C_{10}H_{20}O = 156.0 \text{ g}$

$$\therefore C = \frac{120.0 \text{ g}}{156.0 \text{ g}} \times 100\% = 76.9\%$$

$$H = \frac{20.0 \text{ g}}{156.0 \text{ g}} \times 100\% = 12.8\%$$

$$O = \frac{16.0 \text{ g}}{156.0 \text{ g}} \times 100\% = 10.3\%$$

2. Sodium acetate trihydrate ( $\text{NaCH}_3\text{COO} \cdot 3\text{H}_2\text{O}$ ) is a salt commonly used in pickling foods. Calculate the percentage of water by mass in this compound.

$$\frac{3\text{H}_2\text{O}}{\text{NaCH}_3\text{COO} \cdot 3\text{H}_2\text{O}} \times 100\% =$$

$$\frac{3 \times 18.0 \text{ g/mol}}{136.0 \text{ g/mol}} \times 100\% = 39.7\%$$

3. Trinitrotoluene ( $\text{C}_7\text{H}_5\text{O}_6\text{N}_3$ ) is an explosive commonly referred to as TNT. Calculate the percentage of nitrogen by mass in this compound.

$$\frac{3 \times 14.0 \text{ g/mol}}{227.0 \text{ g/mol}} \times 100\% = 18.5\%$$

4. Complete the following table.

Structural Formula	Molecular Formula	Empirical Formula
<pre>       H H H H               H - C - C - C - C - H                     H H H H           </pre>	$\text{C}_4\text{H}_{10}$	$\text{C}_2\text{H}_5$
<pre>       O H H H              H - O - C - C - C - H                           H H H           </pre>	$\text{C}_4\text{H}_8\text{O}_2$	$\text{C}_2\text{H}_4\text{O}$

5. (a) Explain why the empirical formula alone is not enough to identify a compound.

It is only the simplest molar ratio of the elements and does not necessarily represent the whole number of each atom present.

- (b) What other piece of information will allow you to determine its molecular formula?

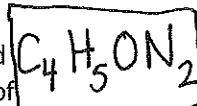
The molar (molecular) mass.

6. A pigment on a suspected forgery is analyzed using X-ray fluorescence and found to contain 0.5068 mol Ba, 0.5075 mol C, and 1.520 mol O. Determine its empirical formula.

→ find simplest ratio of moles.



7. A sample of caffeine is analyzed and found to contain 1.4844 g C, 0.1545 g H, 0.4947 g O and 0.8661 g N. Determine the empirical formula of caffeine.



$$\begin{array}{l} \frac{1.4844 \text{ g}}{12.0 \text{ g/mol}} = 0.1237 \text{ mol} \\ \frac{0.1545 \text{ g}}{1.0 \text{ g/mol}} = 0.1545 \text{ mol} \\ \frac{0.4947 \text{ g}}{16.0 \text{ g/mol}} = 0.0309 \text{ mol} \\ \frac{0.8661 \text{ g}}{14.0 \text{ g/mol}} = 0.0619 \text{ mol} \end{array}$$

8. (a) In a TV series, a forensic anthropologist uses X-ray fluorescence to analyze a dental filling found in skeletal remains. The results of the analysis are provided as *atomic* percentages: 2.85% Al, 87.4% Si, and 9.75% Yb. Convert these results into mass percentages.

Take 100 g sample.

Al - 2.85g

Si - 87.4g

Yb - 9.75g

- (b) These results identified the filling as a commercial restorative material called Heliomolar. How might identifying the material be useful in helping to identify the remains?

Cross-reference with dental records to identify victim.

9. A compound has an empirical formula of  $\text{NH}_2$  and a molar mass of 32.1 g/mol. What is the compound's molecular formula?

$\text{NH}_2 - 16.0 \text{ g/mol}$

$$\therefore \frac{32.1 \text{ g/mol}}{16.0 \text{ g/mol}} = 2$$



10. A sample of ascorbic acid, also known as vitamin C, was analyzed and found to contain 1.080 g C, 0.121 g H, and 1.439 g O. Ascorbic acid has a molar mass of 176.1 g/mol. Determine the molecular formula of ascorbic acid.

$$\frac{1.080 \text{ g}}{12.0 \text{ g/mol}} = 0.0900 \text{ mol}$$

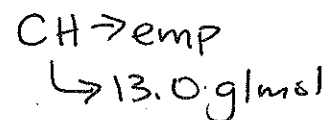
$$\frac{0.121 \text{ g}}{1.0 \text{ g/mol}} = 0.121 \text{ mol}$$

$$\frac{1.439 \text{ g}}{16.0 \text{ g/mol}} = 0.0899 \text{ mol}$$

Simplest ratio	
1	3
1.34	4
1	3



11. A hydrocarbon is a compound containing only carbon and hydrogen. One particular hydrocarbon is 92.29% carbon by mass. If the compound's molar mass is 78.0 g/mol then what is its molecular formula?



$$\frac{78.0}{13.0} = 6 \rightarrow \boxed{\text{C}_6\text{H}_6}$$

12. Cannizzaro determined that a certain compound of carbon and oxygen had a molecular mass of 44.0 u. This meant that a certain volume of this gaseous compound weighed 44.0 times as much as the same volume of hydrogen gas at the same temperature and pressure. This compound was analyzed and found to be 27.3% carbon by mass.

- (a) What is the total mass of carbon in a molecule of this compound?

$$2.0 \text{ g/mol} \times 44 = 88.0 \text{ g/mol}$$

$$\rightarrow 0.273 \times \frac{88.0 \text{ g}}{\text{mol}} = \frac{24.0 \text{ g}}{\text{mol}}$$

- (b) Cannizzaro repeated this experiment on many carbon compounds. Because he never found a molecule with less carbon than this one, Cannizzaro assumed that this molecule had only one carbon atom. Was this assumption correct?