Stoichiometry and the Combustion of Sucrose

Key

Poor Gummy Bears

For each question, show all work, include units and box your answer.

1. A sample of gummy bears were analyzed. It was found that the sugar in gummy bears (sucrose) contains 42.10% carbon, 6.491% hydrogen and 51.41% oxygen. Determine the empirical formula for sucrose.

$C_{1.09}H_{1.99}O_1$ (×11) → $C_{12}H_{22}O_{11}$

$C = \frac{42.10\text{g C}}{} \times \frac{1\text{mol}}{12.01\text{g}} = \frac{3.505\text{mol C}}{3.215\text{mol O}} = 1.09\ \frac{\text{mol C}}{\text{mol O}}$

$\frac{51.41\text{g O}}{} \times \frac{1\text{mol}}{15.99\text{g}} = \frac{3.215\text{mol O}}{3.215\text{mol O}} = 1$

$H = \frac{6.491\text{g H}}{} \times \frac{1\text{mol}}{1.01\text{g}} = \frac{6.427\text{mol H}}{3.215\text{mol O}} = 1.99\ \frac{\text{mol H}}{\text{mol O}}$

*multiply all by 11 to get whole #'s

EF = $C_{12}H_{22}O_{11}$

2. The molar mass of sucrose was experimentally determined to be 342.34 g/mol. Determine the molecular formula of sucrose.

$n = \frac{342.34\text{g/mol}}{342.34\text{g/mol}} = 1$

MF = EF = $C_{12}H_{22}O_{11}$

3. According to the **Nutritional Facts** on a package of gummy bears, there are 17 gummy bears in a serving and each serving contains 21 grams of sugar (sucrose). Calculate the mass of sugar in 1 gummy bear (in grams).

$\frac{21\text{g}}{17\text{GB}} = 1.23\text{g of Sugar/GB}$

→ **1.2 g (2SF)**

4. If the mass of a single gummy bear is approximately 2.2 grams, what percent of the gummy bear is made of sucrose?

$\frac{1.2\text{g}}{2.2\text{g}} \cdot 100 = 54.54\%$

→ **55% (2SF)**

5. Using your answers from #1 & #2, determine how many moles of sucrose are in 1 gummy bear. *(i.e. Convert your answer in #2 from grams to moles using the molar mass of sucrose you calculated from #1.)*

$1.2\text{g sucrose} \times \frac{1\text{mol}}{342.34\text{g}} =$ **0.0035 mol sucrose**

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6. How many molecules of sucrose is this?

$$0.0035\,\text{mol} \times \frac{6.022 \times 10^{23}\ \text{molecules}}{1\,\text{mol}} = 2.1 \times 10^{21}\ \text{molecules}$$

7. When you complete all of these calculations, we will combust a gummy bear, which is mostly composed of sucrose. Below, write and balance the chemical equation for the combustion of sucrose.

$$C_{12}H_{22}O_{11} + 12O_2 \longrightarrow 12CO_2 + 11H_2O$$

8. Using the coefficients written in the balanced equation from #7, what is the stoichiometric mole ratio of sucrose to oxygen needed to complete the reaction?

$$\frac{1\,\text{mol sucrose used}}{12\,\text{mol oxygen needed}}$$

9. Using the stoichiometric ratio from #8, determine how many moles of oxygen will be used if we combust an entire gummy bear. (*Use the number of moles of sugar in 1 gummy bear calculated in #5 and the ratio from #8.*)

1 GB = 1.2g sucrose

$$1.2\,\text{g sucrose} \times \frac{1\,\text{mol sucrose}}{342.34\,\text{g}} \times \frac{12\ \text{mol oxygen needed}}{1\ \text{mol sucrose used}} = 0.042\,\text{mol } O_2 \text{ needed}$$

10. How many grams of oxygen is this?

$$0.042\,\text{mol } O_2 \times \frac{32\,\text{g}}{1\,\text{mol}} = 1.3\,\text{g } O_2 \text{ needed.}$$

11. How many molecules of oxygen is this?

$$1.3\,\text{g } O_2 \times \frac{1\,\text{mol}}{32\,\text{g}} \times \frac{6.02 \times 10^{23}\ \text{molecules}}{1\,\text{mol}} = 2.4 \times 10^{22}\ O_2\ \text{molecules}$$

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12. To generate enough oxygen to combust a gummy bear, we are going to decompose potassium chlorate by heating it. Write and balance the chemical equation that represents this reaction.

$2KClO_3 \rightarrow 2KCl + 3O_2$

13. Determine the molar mass of potassium chlorate.

122.52 g/mol

14. Determine the percent composition of potassium chlorate.

$K = \frac{39.10}{122.52\ g/mol} \cdot 100$

K = 31.91%

$Cl = \frac{35.45}{122.52\ g/mol} \cdot 100$

Cl = 28.93%

$O = \frac{47.97}{122.52\ g/mol} \cdot 100$

O = 39.15%

15. According to your balanced equation in #12, what is the stoichiometric mole ratio between oxygen generated and potassium chlorate decomposed?

$\frac{2\ mol\ KClO_3\ decomposed}{3\ mol\ O_2\ made}$

16. Use your answers from #9 and #15 to determine how many moles of potassium chlorate we should start with.

$1.3g\ O_2\ needed \times \frac{1\ mol\ O_2}{32g} \times \frac{2\ mol\ KClO_3\ needed}{3\ mol\ O_2\ made} = 0.027\ mol\ KClO_3$ needed to react w. 1.3g of O_2

17. How many grams of potassium chlorate is this?

$0.027\ mol \times \frac{122.52g}{1\ mol} = 3.3g\ of\ KClO_3$

18. Read the following 2 pages. List all of the safety hazards and precautions we should take before conducting this experiment.