

A Can Of Cola Contains About 39 Grams Of Sucrose, $C_{12}H_{22}O_{11}$. How Many Moles Of Sucrose Does This Represent?

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Understanding the amount of sugar in your favorite beverage is essential for health awareness and nutritional knowledge. When you pick up a can of cola, you might notice the label indicating a certain amount of sugar, often measured in grams. But what does this translate to in terms of chemical quantity? Specifically, how many moles of sucrose are present in that 39 grams? This question leads us into the fascinating world of chemistry, where we analyze substances based on their molecular composition and quantify them using units like moles. In this article, we'll explore how to convert grams of sucrose into moles, understand the significance of this conversion, and provide insights into the nutritional implications.

Understanding Sucrose: The Chemical Composition

What Is Sucrose?

Sucrose is a common disaccharide carbohydrate, widely known as table sugar. Its chemical formula is $C_{12}H_{22}O_{11}$, which indicates it comprises 12 carbon atoms, 22 hydrogen atoms, and 11 oxygen atoms. Sucrose is naturally found in many plants, especially sugarcane and sugar beets, and is extensively used as a sweetener in foods and beverages.

The Molecular Structure of Sucrose

The molecular structure of sucrose involves a glycosidic bond linking a glucose molecule ($C_6H_{12}O_6$) and a fructose molecule ($C_6H_{12}O_6$). This linkage results in the molecular formula $C_{12}H_{22}O_{11}$. Understanding this structure is crucial because molecular weight calculations depend on the number of atoms and their atomic weights.

Calculating the Molar Mass of Sucrose ($C_{12}H_{22}O_{11}$)

Atomic Weights of Elements Involved

To determine the molar mass of sucrose, we need the atomic weights of the constituent elements:

- Carbon (C): approximately 12.01 g/mol
- Hydrogen (H): approximately 1.008 g/mol
- Oxygen (O): approximately 16.00 g/mol

Step-by-Step Calculation of Molar Mass

Using these atomic weights, we can calculate the molar mass of C₁₂H₂₂O₁₁:

1. Carbon: 12 atoms × 12.01 g/mol = 12 × 12.01 = 144.12 g/mol
2. Hydrogen: 22 atoms × 1.008 g/mol = 22 × 1.008 = 22.176 g/mol
3. Oxygen: 11 atoms × 16.00 g/mol = 11 × 16.00 = 176.00 g/mol

Adding these together:

Molar mass of sucrose = 144.12 + 22.176 + 176.00 = 342.296 g/mol

For simplicity, we'll round this to 342.30 g/mol in further calculations.

Converting Grams of Sucrose to Moles

Understanding the Concept of Moles

A mole is a fundamental unit in chemistry representing Avogadro's number (approximately 6.022×10^{23}) of particles (atoms, molecules, ions, etc.). Converting grams to moles allows chemists and nutritionists to understand the number of molecules involved in a given mass of substance.

Formula for Conversion

To convert grams to moles, use the following formula:

$$\text{Moles of sucrose} = \frac{\text{Mass of sucrose (g)}}{\text{Molar mass of sucrose (g/mol)}}$$

Applying the Formula

Given:

- Mass of sucrose = 39 grams
- Molar mass of sucrose = 342.30 g/mol

Calculating:

$$\text{Moles of sucrose} = \frac{39}{342.30} \approx 0.1138 \text{ mol}$$

Thus, a can of cola containing about 39 grams of sucrose contains approximately 0.114 moles of sucrose.

The Significance of Moles in Nutrition and Chemistry

Why Is Moles Calculation Useful?

Converting grams of sugar to moles is not just an academic exercise; it has practical applications:

- Chemical Reactions: In biochemistry, understanding how many molecules are involved in metabolic reactions.
- Nutritional Science: Estimating the number of sugar molecules ingested helps in understanding energy intake and metabolic processing.
- Food Chemistry: Analyzing the composition of food products to ensure quality control.

Relating Moles to Molecules

Using Avogadro's number, we can find the total number of sucrose molecules in a can of cola:

$$\text{Number of molecules} = \text{Moles} \times 6.022 \times 10^{23}$$

Calculating:

$$0.1138 \times 6.022 \times 10^{23} \approx 6.85 \times 10^{22} \text{ molecules}$$

Therefore, roughly 68.5 trillion sucrose molecules are present in that single can.

Health Implications of Sucrose Content in Beverages

Sugar Intake and Health Risks

Understanding the amount of sucrose in beverages like cola is essential since excessive sugar consumption is linked to:

- Obesity
- Type 2 diabetes
- Tooth decay
- Cardiovascular diseases

A typical 12-ounce (355 ml) can of cola with 39 grams of sucrose contributes significantly to daily sugar intake recommendations.

Recommended Daily Sugar Limits

The World Health Organization (WHO) recommends:

- Less than 25 grams (about 6 teaspoons) of added sugars per day for adults.

Given that a single can contains 39 grams, it exceeds these recommendations, emphasizing the importance of moderation.

Additional Considerations and FAQs

Does the Molar Mass of Sucrose Vary?

The molar mass is a fixed value based on atomic weights; however, minor variations can occur due to isotopic differences or measurement precision.

How Does Temperature Affect Molar Calculations?

Temperature does not affect molar mass calculations directly but can influence physical states and reactions involving sucrose.

What About Other Sugars in Cola?

Cola may contain other sugars like glucose and fructose. Their molar masses differ, and total sugar content can be calculated similarly.

Summary

- A can of cola with 39 grams of sucrose contains approximately 0.114 moles of sucrose.
- The molar mass of sucrose ($C_{12}H_{22}O_{11}$) is roughly 342.30 g/mol.
- Converting grams to moles helps understand the molecular quantity involved and its health implications.
- The vast number of molecules ($\sim 6.85 \times 10^{22}$) illustrates the microscopic scale of sugar molecules ingested.
- Awareness of sugar content aids in making healthier dietary choices.

Conclusion

Understanding how to convert grams of sucrose into moles provides valuable insight into both chemistry and nutrition. Whether you're a student, a health-conscious individual, or a food scientist, these calculations help bridge the gap between the macroscopic world of food labels and the microscopic realm of molecules. Next time you enjoy a cold soda, remember the fascinating chemistry behind that sweet taste and make informed choices about your sugar intake.

References

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Frequently Asked Questions

How do you calculate the number of moles of sucrose in a can of cola containing 39 grams?

To calculate the moles, divide the mass of sucrose (39 grams) by its molar mass (342.3 g/mol for $C_{12}H_{22}O_{11}$). Moles = 39 g / 342.3 g/mol $\approx$ 0.1138 mol.

What is the molar mass of sucrose ($C_{12}H_{22}O_{11}$)?

The molar mass of sucrose is approximately 342.3 grams per mole.

If a can of cola contains 39 grams of sucrose, how many molecules of sucrose does that represent?

Using Avogadro's number (6.022×10^{23} molecules/mol), the number of molecules = $0.1138 \text{ mol} \times 6.022 \times 10^{23} \approx 6.85 \times 10^{22}$ molecules.

Why is it important to know the moles of sucrose in a beverage?

Knowing the moles helps quantify the exact amount of sugar intake, which is useful for dietary planning and understanding nutritional content.

How does the molar mass of sucrose influence the calculation of moles in the cola?

The molar mass acts as a conversion factor, allowing you to convert grams of sucrose into moles by dividing the mass by the molar mass.

What assumptions are made when calculating moles of sucrose in a can of cola?

It is assumed that all 39 grams are pure sucrose without any other substances affecting the calculation, and that the molar mass of sucrose is accurate.

If the sugar content in a can increases to 50 grams, how many moles of sucrose does that represent?

Number of moles = $50 \text{ g} / 342.3 \text{ g/mol} \approx 0.146 \text{ mol}$.

Can the calculation of moles be used to compare sugar content across different beverages?

Yes, calculating moles provides a standardized way to compare the amount of sugar regardless of the beverage's volume or weight.

What is the significance of understanding the molecular quantity of sucrose in food science?

It helps in analyzing the biochemical effects, nutritional value, and potential health impacts of sugar consumption at the molecular level.

Additional Resources

A Can Of Cola Contains About 39 Grams Of Sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$. How Many Moles Of Sucrose Does This Represent?

Introduction

In today's world, carbonated soft drinks like cola are among the most popular beverages globally, enjoyed by millions daily. Beyond their refreshing taste, these beverages also present interesting scientific questions about their chemical composition. One particular curiosity is understanding the amount of sugar, specifically sucrose, present in a typical can of cola. A standard 12-ounce (355 mL) can of cola generally contains approximately 39 grams of sucrose, a common disaccharide with the chemical formula $C_{12}H_{22}O_{11}$. But what does this quantity mean in terms of moles?

This article aims to provide a comprehensive analysis of this question by exploring the concept of moles, the molecular weight of sucrose, and the calculations involved in converting grams to moles. By doing so, we will better appreciate the chemical scale of sugar consumption and the significance behind these numbers.

Understanding the Basics: What Is a Mole?

Before delving into the calculations, it is crucial to understand what a mole represents in chemistry. The mole is a fundamental unit in chemistry used to quantify the amount of a substance.

Definition of a Mole

- A mole is defined as exactly $6.02214076 \times 10^{23}$ elementary entities (atoms, molecules, ions, etc.).
- This number is known as Avogadro's number.
- When chemists say "one mole of sucrose," they mean 6.022×10^{23} molecules of sucrose.

Why Use Moles?

- The mole concept bridges the microscopic world of atoms and molecules with the macroscopic world of grams and liters.
- It allows chemists to relate the mass of a substance to the number of particles it contains, which is essential for chemical reactions, stoichiometry, and nutritional calculations.

The Molecular Structure and Molecular Weight of Sucrose

The Chemical Structure of Sucrose

Sucrose, commonly known as table sugar, is a disaccharide composed of two monosaccharides: glucose and fructose. Its chemical formula is $C_{12}H_{22}O_{11}$,

indicating it contains:

- 12 carbon (C) atoms
- 22 hydrogen (H) atoms
- 11 oxygen (O) atoms

Molecular Weight (Molar Mass) of Sucrose

The molar mass is calculated by summing the atomic masses of all atoms in a molecule:

Element	Atomic Mass (amu)	Number of Atoms	Total Mass (amu)
Carbon (C)	12.011 g/mol	12	$12 \times 12.011 = 144.132$ g/mol
Hydrogen (H)	1.008 g/mol	22	$22 \times 1.008 = 22.176$ g/mol
Oxygen (O)	16.00 g/mol	11	$11 \times 16.00 = 176.00$ g/mol

Total molar mass of sucrose:

$$\text{Molar mass} = 144.132 + 22.176 + 176.00 = \boxed{342.308 \text{ g/mol}}$$

Rounding slightly, the molar mass of sucrose is approximately 342.30 grams per mole.

Calculating the Number of Moles in 39 Grams of Sucrose

Given that a can of cola contains about 39 grams of sucrose, the question becomes: how many moles does this mass represent?

The Basic Formula

The number of moles (n) is calculated as:

$$n = \frac{\text{mass of substance (g)}}{\text{molar mass (g/mol)}}$$

Applying the Values

$$n = \frac{39 \text{ g}}{342.30 \text{ g/mol}} \approx 0.1138 \text{ mol}$$

Result

Therefore, 39 grams of sucrose is approximately 0.114 moles of sucrose.

Significance of the Moles of Sucrose in a Can of Cola

Understanding that a typical can of cola contains about 0.114 moles of sucrose offers several insights:

1. Chemical Quantity Perspective

- The amount of sucrose in a single can is relatively small in terms of molecules—about 6.85×10^{22} molecules (using Avogadro's number).
- Despite the small molecular count, this amount contributes significantly to the beverage's sweetness and caloric content.

2. Nutritional and Health Implications

- Consuming 39 grams of sucrose equates to ingesting roughly 15.6 kilocalories (since each gram of carbohydrate provides approximately 4 kcal).
- This level of sugar intake, if consumed regularly, can impact health, contributing to obesity, diabetes, and other metabolic disorders.

3. Industrial and Food Science Relevance

- The precise measurement of sugar content is vital for food labeling, quality control, and nutritional planning.
- Understanding molar quantities helps food chemists manipulate formulations for desired sweetness and caloric density.

Broader Context: Comparing Sucrose Content in Different Beverages

Variability in Sugar Content

While a standard can contains approximately 39 grams of sucrose, some beverages may contain more or less:

- Energy drinks: sometimes contain similar or higher sugar levels.
- Diet sodas: contain artificial sweeteners instead of sucrose.
- Juices: may contain natural sugars, often in higher amounts.

Impact of Quantity on Moles

For example, a 500 mL bottle with 50 grams of sucrose would contain:

$$\backslash[\\ n = \frac{50 \text{ g}}{342.30 \text{ g/mol}} \approx 0.146 \text{ mol} \\ \backslash]$$

This comparison emphasizes how serving size and sugar concentration influence the number of molecules ingested.

Additional Considerations: Sucrose Dissociation and Metabolism

Dissolution in Beverage

- Sucrose dissolves in water in the beverage, existing as intact molecules.
- The molar quantity determines how much sugar is available for digestion and absorption.

Metabolic Pathway

- Upon ingestion, sucrose is hydrolyzed by the enzyme sucrase into glucose and fructose.
- These monosaccharides are then absorbed into the bloodstream, where they influence blood sugar levels.

Health Implications of Molecular Quantities

- The molar amount correlates with the potential impact on blood glucose.
- For instance, 0.114 mol of sucrose yields approximately 0.057 mol each of glucose and fructose after hydrolysis.

Related Calculations and Extensions

Estimating Calories from Sucrose

- 1 mole of sucrose (342 g) provides about 4 kcal per gram.
- Therefore, 0.114 mol (~39 g) provides:

$$\begin{aligned} & \backslash[\\ & 39 \text{ g} \times 4 \text{ kcal/g} = 156 \text{ kcal} \\ & \backslash] \end{aligned}$$

(Note: This is a simplified estimation; actual caloric contributions depend on digestion efficiency.)

Converting Moles to Molecules

- Number of sucrose molecules in a can:

$$\begin{aligned} & \backslash[\\ & 6.022 \times 10^{23} \times 0.114 \text{ mol} \approx 6.86 \times 10^{22} \\ & \text{molecules} \\ & \backslash] \end{aligned}$$

This staggering number underscores how tiny molecules accumulate into significant quantities at the macroscopic level.

Conclusion

Converting the mass of sucrose in a can of cola into moles reveals the underlying chemical scale of what we consume. A can containing about 39 grams of sucrose corresponds to approximately 0.114 moles of the disaccharide, or about 6.86×10^{22} molecules.

While seemingly a small amount in everyday terms, this quantity significantly influences the beverage's flavor, caloric content, and health implications. Recognizing the relationship between grams and moles enriches our understanding of nutrition science, food chemistry, and the molecular world that underpins our daily dietary choices.

By appreciating these calculations, consumers, health professionals, and food scientists can better grasp the importance of sugar content in diet and its broader biological and chemical contexts.

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