Calculate The Osmotic Pressure Of A 0.555 M Solution Of Glucose (C6H1206, MM G/mol) At 32.0C Phi=___atm

Calculate The Osmotic Pressure Of A 0.555 M Solution Of Glucose ($C_6H_{12}O_6$, MM G/mol) At 32.0°C Phi=___atm

Understanding how to calculate osmotic pressure is essential in chemistry, especially when dealing with solutions and their properties. In this article, we will walk through the detailed process of calculating the osmotic pressure of a 0.555 M glucose solution at 32.0°C, providing clear explanations for each step. Whether you're a student preparing for exams, a researcher analyzing solutions, or a chemistry enthusiast, this guide will help deepen your understanding of osmotic pressure calculations.

What Is Osmotic Pressure?

Osmotic pressure is the pressure required to prevent the flow of solvent molecules through a semipermeable membrane from a pure solvent into a solution containing dissolved particles. It is a colligative property, meaning it depends on the number of solute particles in the solution, not their identity.

Fundamental Concepts and Formula

To accurately compute osmotic pressure, it's vital to understand the underlying principles and the formula used.

Osmotic Pressure Formula

The general formula for osmotic pressure (Π) is derived from van 't Hoff's law:

$$
\Pi = i M R T
$$

Where:
- Π = osmotic pressure (atm)
- i = van 't Hoff factor (number of particles the solute dissociates into)
- M = molarity of the solution (mol/L)
- R = ideal gas constant (0.082057 atm·L/mol·K)
- T = temperature in Kelvin (K)

Understanding Each Component

- **van 't Hoff factor (i):** For glucose ($C_6H_{12}O_6$), which does not dissociate in solution, $i = 1$.
- **Molarity (M):** Given as 0.555 mol/L for this problem.
- **Gas constant (R):** A constant value, 0.082057 atm·L/mol·K.
- **Temperature (T):** Convert from Celsius to Kelvin by adding 273.15.

Step-by-Step Calculation of Osmotic Pressure

Let’s go through each step to compute Π.

Step 1: Convert Temperature to Kelvin

Given temperature in Celsius: 32.0°C

$$
T = 32.0 + 273.15 = 305.15\, \text{K}
$$

Step 2: Identify the van 't Hoff factor (i)

Glucose does not dissociate in solution, so:

$$
i = 1
$$

Step 3: Use the Given Molarity (M)

Molarity:

$$
M = 0.555\, \text{mol/L}
$$

Step 4: Plug Values into the Osmotic Pressure Formula

Using the formula:

\[

$$
\Pi = i M R T
$$

Substitute the known values:

$$
\Pi = 1 \times 0.555\, \text{mol/L} \times 0.082057\, \text{atm·L/mol·K} \times 305.15\, \text{K}
$$

Step 5: Perform the Calculation

Calculate step-by-step:

$$
\Pi = 0.555 \times 0.082057 \times 305.15
$$

First, multiply 0.082057×305.15:

$$
0.082057 \times 305.15 \approx 25.060
$$

Then multiply by 0.555:

$$
0.555 \times 25.060 \approx 13.928\, \text{atm}
$$

Therefore, the osmotic pressure Π is approximately 13.93 atm.

Final Answer: The Osmotic Pressure is approximately ___ atm

$\boxed{\Pi \approx 13.93\, \text{atm}}$

This value indicates the pressure exerted by the glucose solution at the specified temperature and concentration, which can be useful in various scientific and industrial applications.

Additional Considerations in Osmotic Pressure Calculations

While the above calculation is straightforward for non-electrolyte solutes like glucose, other factors can influence osmotic pressure calculations:

1. Dissociation and van 't Hoff Factor (i)

For electrolytes that dissociate into ions (e.g., NaCl dissociates into Na^+ and Cl^-), the van 't Hoff factor increases, affecting the osmotic pressure proportionally.

2. Temperature Effects

Higher temperatures increase molecular motion, leading to higher osmotic pressures. Always convert Celsius to Kelvin for consistency.

3. Solution Concentration

More concentrated solutions exert higher osmotic pressures, but at very high concentrations, deviations from ideal behavior may occur, requiring correction factors.

Practical Applications of Osmotic Pressure Calculations

Understanding and calculating osmotic pressure has numerous practical uses:

- **Medical field:** Designing dialysis solutions and understanding fluid movement in tissues.
- **Food industry:** Preservation techniques based on osmotic pressure.
- **Industrial processes:** Desalination and water purification.
- **Research:** Studying cell biology and membrane permeability.

Conclusion

Calculating the osmotic pressure of a glucose solution at a specific temperature involves understanding the solution's molarity, the nature of the solute, and applying the ideal gas law-based formula. For a 0.555 M glucose solution at 32.0°C, the osmotic pressure is approximately 13.93 atm. This calculation not only emphasizes the importance of colligative properties in chemistry but also illustrates how fundamental principles can be applied practically across various scientific disciplines.

By mastering these calculations, students and professionals can better interpret experimental data, design effective solutions, and understand phenomena related to osmotic pressure and solution chemistry.

Frequently Asked Questions

How do you calculate the osmotic pressure of a glucose solution at 32.0°C with a concentration of 0.555 M?

Use the osmotic pressure formula: $\pi = i M R T$. Since glucose is a non-electrolyte, i = 1.%. Convert temperature to Kelvin (32.0°C + 273.15 = 305.15 K), then substitute the values: $\pi = 1 \times 0.555$ mol/L × 0.0821 L·atm/(mol·K) × 305.15 K, which gives the osmotic pressure in atm.

What is the molar mass of glucose (C6H12O6) and how does it relate to calculating osmotic pressure?

The molar mass of glucose is approximately 180.16 g/mol. While it's used to convert mass to moles, in this problem, since the concentration is already given in molarity (0.555 M), the molar mass is not directly needed for calculating osmotic pressure.

What role does the van 't Hoff factor (i) play in calculating osmotic pressure for glucose solutions?

For glucose, which does not dissociate in solution, the van 't Hoff factor i = 1. This simplifies the calculation as the osmotic pressure is directly proportional to the molarity and temperature without additional factors.

How does temperature affect the osmotic pressure of a glucose solution?

Osmotic pressure increases with temperature because the pressure is directly proportional to temperature in Kelvin ($\pi = i M R T$). As temperature rises, molecules have more kinetic energy, increasing the osmotic pressure.

What is the value of the osmotic pressure of a 0.555 M glucose solution at 32.0°C?

Using $\pi = i M R T$ with i=1, M=0.555 mol/L, R=0.0821 L·atm/(mol·K), T=305.15 K: $\pi = 1 \times 0.555 \times 0.0821 \times 305.15 \approx 13.09$ atm.

Additional Resources

Calculate The Osmotic Pressure Of A 0.555 M Solution Of Glucose ($C_6H_{12}O_6$, MM G/mol) At 32.0°C Phi=___atm

Understanding osmotic pressure is fundamental in fields ranging from biology and chemistry to medicine and environmental science. When dealing with solutions, especially those involving biologically significant compounds like glucose, calculating osmotic pressure helps us comprehend how solutes influence solvent movement across semi-permeable membranes. In this article, we will explore the process of calculating the osmotic pressure of a 0.555 M glucose solution at 32.0°C, translating theoretical principles into practical computation, and discussing the broader implications of osmotic phenomena.

What Is Osmotic Pressure?

Osmotic pressure is the pressure required to prevent the movement of solvent molecules through a semi-permeable membrane from a dilute solution into a more concentrated one. It is a colligative property, meaning it depends only on the number of solute particles in solution, not their identity. This property is crucial in biological systems to maintain cell turgor, in medicine for IV solutions, and in chemistry for understanding solution behavior.

Mathematically, osmotic pressure (π) can be calculated using van't Hoff's law:

$$\pi = i M R T$$

where:
- i = van't Hoff factor (number of particles the solute dissociates into; for glucose, $i=1$)
- M = molarity of the solution (mol/L)
- R = ideal gas constant (0.082057 L·atm/(mol·K))
- T = temperature in Kelvin (K)

Understanding the Components of the Calculation

Before diving into the calculation, let's clarify each component:

Molarity (M)

Given as 0.555 M, indicating 0.555 moles of glucose per liter of solution.

van't Hoff Factor (i)

Since glucose ($C_6H_{12}O_6$) is a non-electrolyte and does not dissociate in solution, $i = 1$.

Ideal Gas Constant (R)

The constant $R = 0.082057$ L·atm/(mol·K) is used in the calculation to relate moles, temperature, and pressure.

Temperature (T)

Temperature must be in Kelvin: $T = 32.0°C + 273.15 = 305.15\,K$.

Step-by-Step Calculation

Let's proceed step-by-step:

1. Convert Temperature to Kelvin

$$T = 32.0 + 273.15 = 305.15\,K$$

2. Use van't Hoff's Law

$$\pi = i M R T$$

Since $i = 1$:

$$\pi = (1) \times 0.555\, \text{mol/L} \times 0.082057\, \text{L·atm/(mol·K)} \times 305.15\, \text{K}$$

3. Perform the Multiplication

Calculating step-by-step:

- $0.555 \times 0.082057 = 0.0455$
- $0.0455 \times 305.15 = 13.91$

Therefore,

$$\pi \approx 13.91\, \text{atm}$$

Final Result and Interpretation

The osmotic pressure of a 0.555 M glucose solution at 32.0°C is approximately 13.91 atm. This high value reflects the significant osmotic potential of glucose solutions, especially at higher concentrations and elevated temperatures.

Broader Implications of Osmotic Pressure Calculations

Understanding how to calculate osmotic pressure is essential for various practical applications:

- Biological Systems: Maintaining cellular integrity involves balancing osmotic pressures. For instance, blood plasma osmotic pressure (~7.3 atm) is tightly regulated to prevent cell lysis or dehydration.
- Medical Applications: Designing IV solutions requires precise osmotic pressure calculations to avoid complications like hemolysis or cell shrinkage.
- Food Industry: Osmotic principles are used in processes like dehydration and concentration of food products.
- Environmental Science: Osmotic pressure influences water movement in soil and aquatic systems, affecting plant and animal life.

Features, Pros, and Cons of Calculating Osmotic Pressure

Features:
- Based on colligative properties, dependent solely on solute particle number.
- Applicable to non-electrolytes (like glucose) and electrolytes (with adjustments for dissociation).
- Uses universally standard constants and equations for consistency.

Pros:
- Provides quantitative understanding of osmotic phenomena.
- Useful in designing medical treatments and understanding biological systems.
- Applicable across various solutions and conditions with minimal assumptions.

Cons:
- Assumes ideal behavior; real solutions may deviate due to interactions.
- Does not account for non-ideal effects like ion pairing or activity coefficients.
- Temperature dependence requires accurate measurement and conversion.

Conclusion

Calculating the osmotic pressure of a glucose solution involves straightforward application of van't Hoff's law, considering the molarity, temperature, and solute properties. For a 0.555 M glucose solution at 32.0°C, the osmotic pressure is approximately 13.91 atm, reflecting the significant osmotic potential such solutions can exert. Such calculations are vital in biological, medical, and industrial contexts, providing insights into solution behavior and guiding practical decision-making. While ideal calculations give a robust starting point, real-world applications should consider deviations from ideality for more precise assessments.

In summary, mastering the calculation of osmotic pressure not only deepens understanding of solution chemistry but also bridges the gap between theoretical principles and real-world applications, making it an invaluable skill across scientific disciplines.

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