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Calculating the molarity of a solution is a fundamental concept in chemistry that involves determining the concentration of a solute in a solvent. In this case, we are tasked with finding the molarity of a solution composed of 49.3 grams of naphthalene ($C_{10}H_8$) dissolved in 217 grams of benzene. This calculation requires understanding the concepts of molar mass, mass-to-mole conversions, and the volume of the solution, as molarity is expressed in moles of solute per liter of solution. In this comprehensive guide, we will walk through each step meticulously, providing insights into the underlying chemistry principles, practical calculation methods, and tips for accuracy.

Understanding the Components of the Solution

Before diving into the calculations, it’s crucial to understand the key components involved:

- Naphthalene ($C_{10}H_8$): An aromatic hydrocarbon with a distinctive odor, commonly used as a moth repellent. Its molecular formula is $C_{10}H_8$, indicating 10 carbon atoms and 8 hydrogen atoms.

- Benzene (C_6H_6): An aromatic solvent with a well-known chemical structure. It’s a liquid at room temperature and acts as the solvent in this solution.

Step 1: Calculating the Molar Mass of Naphthalene ($C_{10}H_8$)

The first step in the calculation involves finding the molar mass of naphthalene, which is essential for converting grams to moles.

Molar Mass Calculation

Element	Atomic Mass (g/mol)	Quantity in Naphthalene	Total contribution (g/mol)
Carbon (C)	12.01	10	12.01 × 10 = 120.1
Hydrogen (H)	1.008	8	1.008 × 8 = 8.064

Total molar mass of $C_{10}H_8$ = 120.1 + 8.064 = 128.164 g/mol

For simplicity and accuracy, we will round this to 128.16 g/mol.

Step 2: Convert Grams of Naphthalene to Moles

Using the molar mass, convert the given mass of naphthalene to moles:

$$
\text{Moles of naphthalene} = \frac{\text{Mass of naphthalene}}{\text{Molar mass of naphthalene}}
$$

$$
= \frac{49.3\, \text{g}}{128.16\, \text{g/mol}} \approx 0.384\, \text{mol}
$$

Result: There are approximately 0.384 moles of naphthalene in the solution.

Step 3: Determine the Volume of the Solution

Molarity is defined as moles of solute per liter of solution. Therefore, we need to find the total volume of the solution.

Important considerations:

- The solvent is benzene, which has a known density at room temperature (~0.8765 g/mL).
- The total mass of the solution is the sum of the masses of naphthalene and benzene.

Calculate the total mass of the solution:

$$
\text{Mass of benzene} = 217\, \text{g}
$$

$$
\text{Total mass of solution} = 49.3\, \text{g} + 217\, \text{g} = 266.3\, \text{g}
$$

Determine the volume of benzene:

Using the density of benzene:

$$
\text{Density} = 0.8765\, \text{g/mL}
$$

$$
\text{Volume of benzene} = \frac{\text{Mass of benzene}}{\text{Density}} = \frac{217\, \text{g}}{0.8765\, \text{g/mL}} \approx 247.6\, \text{mL}
$$

Convert milliliters to liters:

$$
247.6\, \text{mL} = 0.2476\, \text{L}
$$

Note: Since the naphthalene dissolves in benzene, and assuming volume additivity does not significantly alter the volume, the volume of the solution is approximately 0.2476 liters.

Step 4: Calculate the Molarity of the Solution

With the moles of naphthalene and the volume of the solution in liters, molarity is calculated as:

$$
\text{Molarity (M)} = \frac{\text{Moles of}
$$

**solute}}{\text{Volume of solution in liters}}
\]**

**\[
= \frac{0.384\, \text{mol}}{0.2476\, \text{L}}
\approx 1.55\, \text{M}
\]**

Final answer: The molarity of the naphthalene solution is approximately 1.55 mol/L.

Additional Considerations and Tips for Accurate Calculations

1. Density Variations:
Density of benzene varies slightly with temperature; always ensure to use the density corresponding to the temperature at which the measurement was taken for precise calculations.

2. Volume Additivity:
In real solutions, volume may not be strictly additive due to molecular interactions. For approximate molarity calculations, this assumption is acceptable, but for high-precision work, consider density changes upon

solute addition.

3. Significant Figures:
Maintain appropriate significant figures throughout calculations. Here, values are rounded to three decimal places, but depending on the context, more precision may be necessary.

4. Safety Precautions:
Handling benzene requires proper safety measures due to its carcinogenic nature. Always work in a well-ventilated area with personal protective equipment.

Summary of Key Points

- Molar mass of naphthalene ($C_{10}H_8$): approximately 128.16 g/mol
- Moles of naphthalene in 49.3 g: approximately 0.384 mol
- Volume of benzene solvent (217 g): approximately 0.2476 L
- Molarity of the solution: approximately 1.55 mol/L

This detailed approach equips chemistry students and professionals with the methodology to accurately determine the molarity of solutions involving aromatic hydrocarbons and solvents like benzene. Mastery of these calculations is fundamental for tasks in research, laboratory experiments, and industrial applications involving solution chemistry.

Keywords for SEO Optimization:

- Molarity calculation
- Naphthalene solution
- Benzene solvent
- Moles to grams conversion
- Solution concentration
- Chemistry molarity formula
- How to calculate molarity
- Aromatic hydrocarbons in solution
- Laboratory chemistry tips
- Solution preparation calculations

Frequently Asked Questions

How do I calculate the molarity of a solution

containing 49.3g of naphthalene in 217g of benzene?

First, convert the mass of naphthalene to moles using its molar mass, then convert the mass of benzene to liters using its density, and finally divide the moles of naphthalene by the volume of the solution in liters to find the molarity.

What is the molar mass of naphthalene (C10H8)?

The molar mass of naphthalene is approximately 128.17 g/mol, calculated as (10 × 12.01) + (8 × 1.008).

How do I convert 49.3g of naphthalene to moles?

Divide the mass by the molar mass: 49.3 g ÷ 128.17 g/mol ≈ 0.384 moles.

What is the density of benzene, and how does it help in calculating molarity?

The density of benzene is approximately 0.876 g/mL. Using this, you can convert the mass of benzene to volume in liters: volume = mass ÷ density.

How do I find the volume of benzene in liters from its mass?

Convert grams to milliliters using density: 217 g ÷ 0.876 g/mL ≈ 248 mL, then convert to liters: 248 mL ÷ 1000 = 0.248 L.

What is the molarity of the solution with 0.384 moles in 0.248 L?

Molarity = moles ÷ liters: 0.384 mol ÷ 0.248 L ≈ 1.55 M.

Are there any assumptions made in calculating the molarity here?

Yes, it is assumed that the volume of the solution is approximately the same as the volume of benzene before dissolving naphthalene, which is valid for dilute solutions.

Why is it important to use the molar mass of naphthalene in this calculation?

Because molarity is expressed in moles of solute per liter of solution, so converting grams to moles using molar mass is essential.

Can I directly use the mass of benzene to find molarity without converting to volume?

No, molarity requires the volume of the solution in liters. You need to convert the mass of benzene to volume using its density first.

What is the significance of calculating molarity in chemistry?

Calculating molarity helps quantify the concentration of a solution, which is essential for reactions, titrations, and preparing solutions accurately.

Additional Resources

Calculate The Molarity Of A Solution Containing 49.3g Of Dissolved Naphthalene (C10H8) In 217g Benzene

Calculating the molarity of a solution is a fundamental skill in chemistry, essential for understanding concentrations and performing precise reactions. When tasked with determining

the molarity of a solution containing a specific mass of a solute—in this case, naphthalene ($C_{10}H_8$)—dissolved in a certain amount of solvent—benzene (C_6H_6)—the process involves a clear understanding of molar masses, mass-to-mole conversions, and volume calculations. This particular problem provides an excellent opportunity to demonstrate the step-by-step approach to calculating molarity, which is defined as moles of solute per liter of solution. The goal is to convert the given mass of naphthalene into moles, determine the total volume of the solution in liters, and then compute the molarity based on these values.

Understanding the Problem and Key Concepts

Before diving into calculations, it’s essential to grasp the core concepts involved:

- Molarity (M): Expressed as moles of solute per liter of solution.
- Moles: A measure of the amount of substance, calculated by dividing mass by molar mass.
- Molar Mass: Sum of atomic masses of all atoms

in a molecule.
- Solution Volume: The total volume of the solvent (benzene) plus any volume contribution from dissolved solute; often approximated by the volume of the solvent if the solute's volume is negligible.

In this problem, the main steps involve:

1. Calculating the molar mass of naphthalene.
2. Converting the given mass of naphthalene to moles.
3. Determining the total volume of the solution in liters.
4. Computing the molarity using the number of moles and the volume.

Step 1: Calculating the Molar Mass of Naphthalene ($C_{10}H_8$)

The molecular formula for naphthalene is $C_{10}H_8$, meaning it contains:

- 10 carbon atoms
- 8 hydrogen atoms

Using atomic masses from the periodic table:

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

Calculating molar mass:

$$
\text{Molar mass of C10H8} = (10 \times 12.01\, \text{g/mol}) + (8 \times 1.008\, \text{g/mol})
$$

$$
= 120.10\, \text{g/mol} + 8.064\, \text{g/mol}
= 128.164\, \text{g/mol}
$$

For simplicity and significant figures, we can round to:

$$
\text{Molar mass of C10H8} \approx 128.16\, \text{g/mol}
$$

Step 2: Converting Mass of Naphthalene to Moles

Given mass of naphthalene:

$$
\text{Mass} = 49.3\, \text{g}
$$

Number of moles:

$$
\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{49.3\, \text{g}}{128.16\, \text{g/mol}}
$$

Calculating:

$$
\text{Moles} \approx 0.384\, \text{mol}
$$

This is the amount of naphthalene dissolved in the solution.

Step 3: Determining the Total Volume of the Solution

The problem states that the naphthalene is dissolved in 217 g of benzene. To find molarity, we need the volume of the solution in liters. Since the volume of the solution is not directly provided, we generally assume that the volume of the solution is approximately equal to the volume of the solvent (benzene), especially at dilute concentrations.

Estimating the volume of benzene:

- Density of benzene: approximately 0.879 g/mL at room temperature.
- Convert grams of benzene to milliliters:

$$
\text{Volume of benzene} = \frac{\text{Mass}}{\text{Density}} = \frac{217\, \text{g}}{0.879\, \text{g/mL}} \approx 246.8\, \text{mL}
$$

- Convert milliliters to liters:

$$
246.8\, \text{mL} = 0.2468\, \text{L}
$$

Note: This approximation assumes the volume contributed by the dissolved naphthalene is

negligible, which is reasonable for dilute solutions.

Step 4: Calculating the Molarity

Now, using the number of moles of naphthalene and the volume of the solution:

$$
\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}} = \frac{0.384\, \text{mol}}{0.2468\, \text{L}}
$$

Calculating:

$$
\text{Molarity} \approx 1.556\, \text{M}
$$

Rounding to an appropriate number of significant figures (three), the molarity is approximately:

$$
\boxed{1.56\, \text{M}}
$$

\]

Additional Considerations and Features of the Calculation

When calculating molarity in practical scenarios, several factors can influence the accuracy and precision of the result:

Features:

- Use of precise molar masses: Ensures accuracy in moles calculation.
- Density-based volume estimation: Allows for a realistic approximation of the solution volume.
- Assumption of negligible volume change upon dissolution: Valid for dilute solutions, simplifying calculations.
- Significant figures: Maintaining consistent significant figures reflects the precision of the data.

Pros:

- Straightforward method for solution concentration calculation.

- Utilizes basic principles of stoichiometry.
- Adaptable to various solutes and solvents.

Cons:

- Neglects volume contraction that may occur upon dissolution at higher concentrations.
- Assumes ideal behavior, which may not always be accurate in real-world solutions.
- Relies on the assumption that density remains constant and accurate at the specified temperature.

Conclusion

Calculating the molarity of a solution containing 49.3 g of naphthalene dissolved in 217 g of benzene involves a systematic approach grounded in fundamental chemical principles. By first determining the molar mass of naphthalene, converting the given mass to moles, estimating the solution volume from the solvent's mass and density, and finally dividing the moles by the volume in liters, we arrive at a molarity of approximately 1.56 M. This process underscores the importance of

understanding molecular weights, unit conversions, and solution properties in chemistry. Mastery of these calculations is vital for chemists in both academic research and industrial applications, ensuring precise formulation and understanding of solution concentrations.

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