

A Student Dissolves 5.7 G Of Biphenyl (C₁₂H₁₀) In 425. ML Of A Solvent With A Density Of 1.06 G/mL. The

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Understanding the process of dissolving substances is fundamental in chemistry, especially when dealing with organic compounds like biphenyl. In this article, we will explore the detailed steps involved when a student dissolves 5.7 grams of biphenyl (C₁₂H₁₀) in 425 mL of a solvent with a density of 1.06 g/mL. We will analyze the calculations needed to determine the concentration of the solution, discuss the significance of the solvent's density, and provide insights into how this process relates to real-world applications in chemistry laboratories and industries.

Introduction to Biphenyl and Its Properties

Biphenyl, also known as diphenyl, is an aromatic hydrocarbon composed of two benzene rings connected by a single bond. Its molecular formula is C₁₂H₁₀, and it is a colorless solid at room temperature. Biphenyl is widely used in the synthesis of polychlorinated biphenyls (PCBs), in organic synthesis, and as a heat transfer medium in certain industrial applications.

Some key properties of biphenyl include:

- Melting point: approximately 69.2°C
- Boiling point: around 255°C
- Density: approximately 1.04 g/mL at room temperature
- Low solubility in water but good solubility in organic solvents like benzene, ethanol, and acetone

Understanding these properties helps chemists choose appropriate solvents and conditions for dissolving biphenyl effectively.

Calculating the Mass and Volume of the Solvent

Given data:

- Mass of biphenyl (solute): 5.7 grams
- Volume of solvent: 425 mL
- Density of solvent: 1.06 g/mL

To determine the mass of the solvent used, we multiply its volume by its density:

$$\text{Mass of solvent} = \text{Volume} \times \text{Density} = 425 \text{ mL} \times 1.06 \text{ g/mL} = 450.5 \text{ g}$$

This mass is essential when calculating the solution's concentration, especially in molarity or molality.

Understanding Solution Concentration

Solution concentration quantifies how much solute is dissolved in a given amount of solvent or solution. The most common units include:

- Molarity (M): moles of solute per liter of solution
- Mass percent (%): grams of solute per 100 grams of solution
- Molality (m): moles of solute per kilogram of solvent

In this scenario, calculating molarity provides a clear understanding of the solution's strength for laboratory applications.

Calculating Moles of Biphenyl

First, determine the molar mass of biphenyl:

- C: $12.01 \text{ g/mol} \times 12 = 144.12 \text{ g/mol}$
- H: $1.008 \text{ g/mol} \times 10 = 10.08 \text{ g/mol}$
- Total molar mass = $144.12 + 10.08 = 154.2 \text{ g/mol}$

Number of moles in 5.7 grams:

$$\text{Moles of biphenyl} = 5.7 \text{ g} / 154.2 \text{ g/mol} \approx 0.0370 \text{ mol}$$

Calculating Solution Molarity

Assuming the total volume of the solution is approximately the volume of the solvent (since the amount of biphenyl is small relative to the solvent volume), we convert 425 mL to liters:

$$\text{Volume in liters} = 425 \text{ mL} / 1000 = 0.425 \text{ L}$$

Now, molarity (M) is:

$$\text{Molarity} = \text{moles of solute} / \text{liters of solution} = 0.0370 \text{ mol} / 0.425 \text{ L} \approx 0.087 \text{ M}$$

This molarity indicates a dilute biphenyl solution, useful for various analytical and synthetic procedures.

The Role of Solvent Density and Its Implications

The solvent's density plays a crucial role in determining solution concentrations and physical properties. With a density of 1.06 g/mL, the solvent is slightly denser than water, implying it might be an organic solvent like benzene, toluene, or a similar aromatic solvent.

Why Does Density Matter?

- **Calculating solution mass:** Density allows accurate determination of solvent mass from its volume.
- **Understanding solvent behavior:** Density influences solubility, boiling point, and viscosity.
- **Safety considerations:** Denser organic solvents may require special handling due to their flammability or toxicity.

Practical Applications

- Preparation of solutions: Precise knowledge of solvent density ensures accurate solution concentrations.
- Industrial processes: Density measurements inform process control in

manufacturing pharmaceuticals, dyes, and polymers.

- Environmental monitoring: Density can help identify solvent purity and contamination levels during waste management.

Step-by-Step Process for Dissolving Biphenyl

To effectively dissolve biphenyl in the solvent, follow these steps:

1. **Measure the solvent:** Use a graduated cylinder or volumetric flask to measure 425 mL of the solvent.
2. **Calculate the solvent's mass:** Multiply the volume by the density (as shown earlier) to get approximately 450.5 g.
3. **Weigh the biphenyl:** Use an analytical balance to measure 5.7 g of biphenyl.
4. **Mix the substances:** Add biphenyl slowly to the solvent while stirring to promote uniform dissolution.
5. **Ensure complete dissolution:** Continue stirring until biphenyl is fully dissolved, which may require gentle heating if necessary, considering biphenyl's melting point and solubility.

Safety and Handling Considerations

Handling biphenyl and organic solvents requires adherence to safety protocols:

- Work in a well-ventilated fume hood to avoid inhaling vapors.
- Wear appropriate personal protective equipment (PPE) such as gloves, goggles, and lab coats.
- Store chemicals in properly labeled containers away from heat sources.
- Dispose of waste solutions following environmental regulations.

Real-World Applications of Biphenyl Solutions

Understanding how to prepare and analyze biphenyl solutions is vital in various industries:

- **Organic Synthesis:** Biphenyl solutions are used as solvents or starting materials in chemical reactions.
- **Pharmaceutical Industry:** Precise solution preparation is essential for drug formulation and testing.
- **Materials Science:** Biphenyl-based compounds are used in developing polymers and electronic materials.
- **Environmental Testing:** Monitoring biphenyl levels in waste streams helps assess pollution and compliance with environmental standards.

Conclusion

Dissolving 5.7 grams of biphenyl in 425 mL of solvent with a density of 1.06 g/mL involves careful calculation and understanding of physical properties. By determining the molarity, considering the solvent's density, and following proper procedures, chemists can prepare solutions with desired concentrations for research and industrial purposes. The process highlights the importance of precise measurements, safety, and application knowledge in chemistry.

Whether used in laboratory experiments or large-scale manufacturing, mastering the dissolution process of biphenyl and similar compounds is essential for achieving accurate results and advancing scientific knowledge.

Frequently Asked Questions

What is the mass of biphenyl dissolved in the solvent?

The mass of biphenyl is 5.7 grams, as given in the problem statement.

How do you calculate the volume of the solvent used to dissolve biphenyl?

The volume of the solvent is given as 425 mL; no calculation is needed unless converting units or finding concentration.

What is the density of the solvent, and how is it relevant?

The density of the solvent is 1.06 g/mL, which can be used to find the mass of the solvent if needed, or to calculate solution concentrations.

How do you determine the mass of the solvent from its volume and density?

Mass of the solvent = volume $\times$ density = 425 mL $\times$ 1.06 g/mL = 450.5 g.

What is the molarity of biphenyl in the solution?

First, calculate the molar mass of biphenyl (C₁₂H₁₀): (12 $\times$ 12.01) + (10 $\times$ 1.008) = 144.12 + 10.08 = 154.2 g/mol. Then, molarity = moles of biphenyl / liters of solution = (5.7 g / 154.2 g/mol) / 0.425 L $\approx$ 0.088 mol / 0.425 L $\approx$ 0.207 M.

What is the significance of knowing the density of the solvent in this context?

Knowing the density helps convert the volume to mass, which is useful for calculating concentrations, solubility, or preparing solutions with precise molarity.

How would temperature affect the dissolution process of biphenyl in the solvent?

Temperature can influence the solubility of biphenyl; higher temperatures generally increase solubility, affecting how much biphenyl can be dissolved in the solvent.

Additional Resources

A Student Dissolves 5.7 G Of Biphenyl (C₁₂H₁₀) In 425 mL Of A Solvent With A Density Of 1.06 G/mL: An Investigative Analysis

Introduction

The process of dissolving a solid compound into a solvent is fundamental in various fields, including chemistry, pharmacology, and materials science. In particular, understanding solubility behavior provides insights into molecular interactions, thermodynamics, and potential applications. This investigative article delves into a specific case: a student dissolves 5.7 grams of biphenyl (C₁₂H₁₀) in 425 mL of a solvent with a density of 1.06

g/mL. The purpose is to analyze the underlying principles, perform detailed calculations, and interpret the implications of these findings in a broader scientific context.

Background: Biphenyl and Its Solubility Characteristics

Chemical Structure and Properties of Biphenyl

Biphenyl, also known as diphenyl, is an aromatic hydrocarbon composed of two connected benzene rings via a single bond. Its molecular formula is $C_{12}H_{10}$, and it exhibits:

- Molecular weight: 154.21 g/mol
- Physical state: Solid at room temperature
- Appearance: Colorless, crystalline solid with a melting point of approximately 69.2°C

Solubility Profile

Biphenyl is relatively soluble in organic solvents such as benzene, toluene, and chlorinated hydrocarbons. Its solubility in water is minimal, typically less than 0.01 g per 100 mL, due to its nonpolar aromatic structure. Understanding its solubility in various solvents can inform its applications in chemical syntheses and industrial processes.

The Experimental Context

Objective of the Dissolution

The student aims to dissolve 5.7 g of biphenyl into a specified volume of solvent, measuring 425 mL. The solvent's density is given as 1.06 g/mL, which suggests it is likely an organic solvent with moderate density—possibly toluene or a similar aromatic solvent.

Significance of Accurate Measurements

Precise calculation of solubility and concentration is critical. The student must consider:

- The actual mass of biphenyl
- The volume of the solvent
- The density of the solvent to determine the solvent's mass
- The molarity or molality of the solution for further analysis

Detailed Calculations and Analysis

1. Determining the Mass of the Solvent

Given:

- Volume of solvent = 425 mL
- Density of solvent = 1.06 g/mL

Calculating the total mass of the solvent:

$$\begin{aligned}\text{_mass of solvent_} &= \text{volume} \times \text{density} \\ &= 425 \text{ mL} \times 1.06 \text{ g/mL} \\ &= 450.5 \text{ g}\end{aligned}$$

This precise mass calculation provides the basis for further concentration and solubility calculations.

2. Calculating Moles of Biphenyl Dissolved

Given:

- Mass of biphenyl = 5.7 g
- Molecular weight of biphenyl = 154.21 g/mol

Number of moles:

$$\begin{aligned}\text{_moles of biphenyl_} &= \text{mass} / \text{molar mass} \\ &= 5.7 \text{ g} / 154.21 \text{ g/mol} \\ &\approx 0.0370 \text{ mol}\end{aligned}$$

3. Calculating the Concentration of the Solution

The concentration can be expressed as molarity (mol/L). First, convert the volume of solvent from mL to liters:

$$\text{Volume in liters} = 425 \text{ mL} / 1000 = 0.425 \text{ L}$$

Now, molarity:

$$\begin{aligned}\text{_Molarity (M)_} &= \text{moles} / \text{volume in liters} \\ &= 0.0370 \text{ mol} / 0.425 \text{ L} \\ &\approx 0.0871 \text{ mol/L}\end{aligned}$$

This indicates the solution has a molarity of approximately 0.087 mol/L, which provides a quantitative basis for evaluating solubility.

4. Assessing Solubility Limits

Given the typical solubility of biphenyl in common organic solvents, determining whether this amount exceeds or remains within solubility limits is crucial. Literature indicates biphenyl's solubility in toluene at room temperature can reach approximately 2 g per 100 mL. Let's compare:

- Dissolved amount: 5.7 g in 425 mL

- Solubility in toluene: ~2 g / 100 mL

Maximum dissolved biphenyl in 425 mL (if fully saturated):

$$\begin{aligned} &= (2 \text{ g} / 100 \text{ mL}) \times 425 \text{ mL} \\ &= 8.5 \text{ g} \end{aligned}$$

Since the student dissolves only 5.7 g, which is less than 8.5 g, it is likely that the biphenyl is fully soluble in the solvent at room temperature, assuming the solvent is similar to toluene.

Broader Scientific Implications

Understanding the Dissolution Process

The process hinges on molecular interactions—nonpolar biphenyl interacts favorably with nonpolar solvents through London dispersion forces. The thermodynamics involve a balance between enthalpic and entropic contributions, influencing solubility.

Practical Applications

- Chemical Synthesis: Dissolving biphenyl accurately in solvents is essential for reactions such as halogenation or nitration.
- Purification Processes: Knowledge of solubility helps in recrystallization and purification.
- Material Science: Biphenyl's role in liquid crystals and organic electronics depends on its solubility in various solvents.

Environmental and Safety Considerations

Handling biphenyl and organic solvents requires adherence to safety protocols due to toxicity and flammability. Proper disposal and ventilation are mandatory in laboratory settings.

Critical Evaluation and Further Research

Potential Sources of Error

- Measurement inaccuracies: Errors in weighing or volume measurement.
- Temperature fluctuations: Solubility varies with temperature.
- Impurities: Presence of impurities can alter solubility behavior.

Suggested Future Experiments

- Conducting solubility tests at different temperatures to establish a solubility curve.

- Using spectroscopic methods to confirm the dissolution extent.
- Comparing solubility in various solvents to optimize for industrial processes.

Conclusion

The case study of dissolving 5.7 g of biphenyl in 425 mL of a solvent with a density of 1.06 g/mL exemplifies fundamental principles of solution chemistry. Precise calculations reveal that the solvent volume corresponds to approximately 450.5 g, and the molarity of the resulting solution is roughly 0.087 mol/L. The solubility appears sufficient for complete dissolution under typical conditions, aligning with literature data for similar aromatic solvents like toluene.

This investigation underscores the importance of meticulous measurement and comprehension of molecular interactions in solubility phenomena. Such insights are pivotal across disciplines, guiding the design of chemical processes, ensuring safety, and advancing scientific knowledge.

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