A Chemistry Graduate Student Is Given 300.mL Of A 0.80M Diethylamine C2H52NH Solution. Diethylamine Is

A Chemistry Graduate Student Is Given 300.mL Of A 0.80M Diethylamine C2H52NH Solution. Diethylamine Is a versatile organic compound widely used in chemical synthesis, pharmaceuticals, and industrial applications. Understanding its properties, behavior in solution, and chemical interactions is crucial for chemistry students and professionals alike. In this comprehensive guide, we explore diethylamine's chemical structure, physical and chemical properties, methods for preparing and diluting solutions, and its significance in various chemical processes.

Introduction to Diethylamine

Diethylamine (C4H11N or C2H52NH) is an organic amine characterized by a nitrogen atom bonded to two ethyl groups. Its chemical structure imparts unique properties, making it a valuable reagent and intermediate in organic synthesis.

Chemical Structure and Nomenclature

- **Chemical Formula:** C4H11N
- **Structural Formula:** (C2H5)2NH
- **IUPAC Name:** N,N-Diethylamine

The molecule features a nitrogen atom bonded to two ethyl groups and one hydrogen atom, classifying it as a secondary amine.

Physical Properties

- **Appearance:** Colorless liquid
- **Odor:** Fishy, ammonia-like
- **Boiling Point:** Approximately 55°C (131°F)

- **Density:** About 0.726 g/mL at 20°C
- **Solubility:** Miscible with water, ethanol, and ether

Understanding these physical properties is essential for handling diethylamine safely and effectively in laboratory settings.

Chemical Properties and Reactivity

Diethylamine's behavior in chemical reactions is primarily driven by its amine group, which can act as a nucleophile and a base.

Basicity

As a secondary amine, diethylamine exhibits significant basicity, with a pKa around 10.7. This makes it capable of accepting protons and participating in acid-base reactions.

Nucleophilicity

Its lone pair of electrons on nitrogen makes diethylamine a good nucleophile, enabling it to attack electrophilic centers in organic molecules, such as carbonyl carbons, facilitating various substitution and addition reactions.

Reactivity with Acids

- Forms corresponding ammonium salts upon protonation
- Commonly reacts with acids like HCl, H_2SO_4, and organic acids to produce soluble salts

Oxidation and Other Reactions

While relatively resistant to oxidation, diethylamine can undergo oxidation to produce diethylimine or other oxidized derivatives under specific conditions, which are relevant in organic synthesis and industrial processes.

Preparation and Dilution of Diethylamine Solutions

Given the initial solution of 0.80 M diethylamine in 300 mL, understanding how to work with and dilute this solution is vital for experimental procedures.

Understanding Molarity and Concentration

- **Molarity (M):** Moles of solute per liter of solution
- **Given Data:** 0.80 M, 300 mL (0.3 L)

Calculating the Number of Moles

1. Use the formula: *moles = molarity × volume (L)*
2. Calculation: 0.80 mol/L × 0.3 L = 0.24 mol

This indicates that the solution contains 0.24 moles of diethylamine.

Dilution Procedures

To prepare solutions of different concentrations, dilution is performed using the formula:

$$C_1V_1 = C_2V_2$$

where:

- **C_1:** Initial concentration (0.80 M)
- **V_1:** Volume of initial solution needed
- **C_2:** Desired concentration
- **V_2:** Final volume of diluted solution

Example: Preparing 100 mL of 0.20 M Diethylamine Solution

1. Plug into the dilution formula: $0.80\ M \times V_1 = 0.20\ M \times 100\ mL$
2. Calculate V_1: $V_1 = (0.20 \times 100) / 0.80 = 25\ mL$
3. Procedure:
    - Measure 25 mL of the original 0.80 M solution
    - Add it to a volumetric flask
    - Fill to the 100 mL mark with distilled water

Proper technique ensures accurate dilutions, critical for experiments and industrial applications.

Safety and Handling of Diethylamine

Due to its chemical properties, diethylamine requires careful handling.

Hazards and Precautions

- **Flammability:** Flammable liquid; keep away from heat and open flames
- **Irritation:** Can cause skin and eye irritation; wear appropriate PPE
- **Inhalation:** Vapors can irritate respiratory tract; use in a well-ventilated area or fume hood
- **Reactivity:** Reacts with acids, oxidizers, and incompatible substances

First Aid Measures

- **Skin contact:** Wash with soap and water; seek medical attention if

irritation persists

- **Eye contact:** Rinse immediately with plenty of water; consult an eye specialist
- **Inhalation:** Move to fresh air; seek medical help if symptoms continue
- **Ingestion:** Do not induce vomiting; seek immediate medical attention

Storage Guidelines

- Store in a cool, dry, well-ventilated area
- Keep container tightly closed in a flammable liquids cabinet
- Avoid contact with oxidizing agents and acids

Applications of Diethylamine

Diethylamine's chemical properties make it valuable across multiple fields:

Organic Synthesis

- Intermediate in the production of pharmaceuticals
- Used in the synthesis of dyes, agrochemicals, and rubber accelerators
- Component in the formation of heterocyclic compounds

Pharmaceutical Industry

- Precursor in drug synthesis, including antihistamines and antidepressants
- Involved in the manufacture of local anesthetics

Industrial Applications

- Corrosion inhibitors
- Chemical reagents in laboratory and manufacturing settings
- Part of formulations for cleaning agents and lubricants

Environmental Considerations

Proper disposal and handling of diethylamine are essential to prevent environmental contamination. Waste solutions should be neutralized and disposed of following local regulations.

Conclusion

Diethylamine is a fundamental secondary amine with diverse applications in chemistry and industry. Its physical and chemical characteristics, such as basicity and nucleophilicity, allow it to participate actively in organic synthesis and manufacturing processes. For a chemistry graduate student working with solutions like the 0.80 M diethylamine in 300 mL, understanding preparation, dilution, and safety protocols is essential for efficient and safe laboratory work. Mastery of these concepts enables effective experimentation and innovation in chemical research and production.

References and Further Reading

1. Smith, M. B., & March, J. (2007). March's Advanced Organic Chemistry. Wiley.
2. Silverstein, R. M., Webster, F. X., & Kiemle, D. J. (2005). Spectrometric Identification of Organic Compounds. Wiley.
3. Safety Data Sheet (SDS) for Diethylamine. Available from chemical

Frequently Asked Questions

What is diethylamine and its chemical formula?

Diethylamine is an organic compound with the chemical formula C4H11N, consisting of a nitrogen atom bonded to two ethyl groups.

What is the significance of the 0.80 M concentration in the solution?

The 0.80 M concentration indicates that there are 0.80 moles of diethylamine dissolved per liter of solution, reflecting its molarity.

How much diethylamine (in grams) is present in the 300 mL of 0.80 M solution?

First, convert volume to liters: 300 mL = 0.3 L. Then, multiply by molarity: 0.80 mol/L × 0.3 L = 0.24 mol. Molar mass of diethylamine is approximately 73.14 g/mol, so: 0.24 mol × 73.14 g/mol ≈ 17.55 grams.

What is diethylamine commonly used for in chemistry?

Diethylamine is commonly used as a solvent, a base in organic synthesis, and as an intermediate in the production of pharmaceuticals and agrochemicals.

Is diethylamine considered a weak or strong base?

Diethylamine is considered a weak base because it can accept protons but does not fully dissociate in water.

How does diethylamine behave in an aqueous solution?

In water, diethylamine acts as a weak base, accepting protons to form diethylammonium ions, and slightly increases the pH of the solution.

What safety precautions should be taken when handling diethylamine?

Diethylamine is a corrosive and volatile amine; proper safety measures include working in a well-ventilated area, wearing gloves and protective eyewear, and avoiding inhalation or skin contact.

Can you prepare a 1 M solution of diethylamine from the given solution?

Yes, by diluting the 0.80 M solution with water. To prepare 100 mL of 1 M solution, you would need to dilute a concentrated volume accordingly, but since the initial concentration is 0.80 M, a higher concentration solution is not possible; instead, you can dilute the 0.80 M solution to a lower concentration or prepare a more concentrated solution via other methods.

What is the pKa of diethylamine?

The pKa of diethylamine is approximately 10.7, indicating its basic strength.

How does the molarity of diethylamine affect its buffering capacity?

Higher molarity solutions of diethylamine can provide greater buffering capacity, meaning they can resist pH changes more effectively in acid-base reactions.

Additional Resources

A Chemistry Graduate Student Is Given 300 mL Of A 0.80 M Diethylamine $(C_2H_5)_2NH$ Solution: An In-Depth Analysis

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Introduction: The Significance of Diethylamine in Chemical Research

Diethylamine $(C_2H_5)_2NH$ is a versatile secondary amine that finds widespread application in organic synthesis, medicinal chemistry, and industrial manufacturing. Its unique chemical properties, such as basicity and nucleophilicity, make it a valuable reagent and intermediate. For a graduate student embarking on research projects involving amines, understanding the properties, preparation, and reactions of diethylamine is essential. The scenario of being given 300 mL of a 0.80 M solution offers a practical context to explore concepts such as solution concentration, molar calculations, acid-base behavior, and potential applications.

This article provides a comprehensive review of diethylamine, covering its chemical structure, physical and chemical properties, methods of preparation, reactivity, and implications of the given solution. It aims to serve as a detailed resource for students and researchers seeking to deepen their understanding of this important compound.

Understanding Diethylamine: Structure, Properties, and Significance

Chemical Structure and Basic Characteristics

Diethylamine $(C_2H_5)_2NH$ is classified as a secondary amine, characterized by a nitrogen atom bonded to two ethyl groups and one hydrogen atom. Its structure can be represented as:

- Molecular Formula: $C_4H_{11}N$
- Molecular Weight: Approximately 73.14 g/mol

The nitrogen atom in diethylamine harbors a lone pair of electrons, conferring basicity and nucleophilicity. The ethyl groups attached to nitrogen influence its physical properties, such as boiling point and solubility, and affect its reactivity profile.

Physical Properties:

- Appearance: Colorless, with a pungent, fishy odor typical of amines.
- Boiling Point: About 55°C (131°F), indicative of its relatively low molecular weight and hydrogen bonding capabilities.
- Solubility: Highly soluble in water, ethanol, and other polar solvents due to its amine group.

Chemical Properties:

- Basicity: Diethylamine is a weak to moderately strong base, capable of accepting protons.
- Nucleophilicity: The lone pair on nitrogen makes it readily attack electrophiles.
- Reactivity: Susceptible to oxidation, alkylation, and acylation reactions.

Understanding these properties is foundational for predicting how diethylamine will behave in various chemical contexts.

Preparation and Commercial Availability of Diethylamine

Methods of Synthesis

Diethylamine is commonly produced via industrial and laboratory synthesis routes:

1. Ammonolysis of Ethyl Halides:
Ethyl halides (like ethyl chloride) react with ammonia under controlled conditions to produce primary, secondary, and tertiary amines, including diethylamine. The reaction proceeds via nucleophilic substitution, and careful control of reaction conditions can favor diethylamine formation.

2. Reaction of Ethyl Lithium or Ethyl Grignard Reagents:
Organometallic reagents can be reacted with ammonia or amines to generate secondary amines selectively.

3. Hydrogenation of Nitroso Compounds:
Certain nitroso derivatives can be hydrogenated to produce secondary amines.

Commercial Availability:
Diethylamine is widely available from chemical suppliers in various purities and quantities, often as a solution in water or ethanol, making it convenient for laboratory use.

Analyzing the Given Solution: Concentration, Volume, and Moles

Calculating the Number of Moles in the Solution

Given data:

- Volume of solution, V = 300 mL = 0.300 L
- Concentration, C = 0.80 M (mol/L)

The number of moles of diethylamine can be calculated using the molarity formula:

$$
\text{Moles} = \text{Concentration} \times \text{Volume}
$$

$$
\text{Moles} = 0.80\, \text{mol/L} \times 0.300\, \text{L} = 0.24\, \text{mol}
$$

Implication:
This indicates the solution contains approximately 0.24 moles of diethylamine, which corresponds to roughly 17.6 grams (since molar mass ≈ 73.14 g/mol):

$$
\text{Mass} = 0.24\, \text{mol} \times 73.14\, \text{g/mol} \approx 17.56\, \text{g}
$$

This quantification is vital for planning further experiments, such as titrations, reactions, or calculations of dilution.

Physical and Chemical Behavior of the Solution

Properties of the 0.80 M Diethylamine Solution

The solution’s properties influence how it can be used and handled:

- pH and Basicity:
Given the basic nature of diethylamine, the solution will have a pH likely in the range of 11–12, making it strongly alkaline. This impacts how the solution interacts with acids and other reactive species.

- Solvent Compatibility:
Its high solubility in water allows for homogeneous reactions, but the solution’s pH must be considered when mixing with other reagents.

- Stability:
Diethylamine solutions are relatively stable but should be stored in tightly sealed containers to prevent oxidation and evaporation.

Handling Precautions:
Due to its pungent odor and potential irritant properties, appropriate safety measures—including gloves, goggles, and fume hoods—are essential.

Reactivity and Applications of Diethylamine

Reactivity Profile

Diethylamine’s reactivity stems from its nucleophilic nitrogen:

- Acid-Base Reactions:
It readily reacts with acids to form ammonium salts, which are often used as intermediates or for purification.

- Alkylation:
It can undergo alkylation to produce tertiary amines, useful in synthesizing compounds like quaternary ammonium salts.

- Acylation:
Reaction with acyl chlorides produces amides, relevant in peptide synthesis and pharmaceuticals.

- Oxidation:
Under oxidative conditions, diethylamine can be converted into nitroso, nitro, or N-oxide derivatives.

Industrial and Laboratory Applications:

- Organic Synthesis:
As a base and nucleophile, it facilitates various transformations such as Mannich reactions, alkylations, and acylations.

- Pharmaceuticals:
It is a precursor in the synthesis of drugs and active pharmaceutical ingredients, including antihistamines and beta-blockers.

- Corrosion Inhibitors:
Due to its basicity, diethylamine derivatives are used to prevent corrosion in pipelines.

Implications of the Solution for Research and Experimentation

Titration and Analytical Chemistry:
Knowing the molarity and volume allows precise titration calculations when reacting diethylamine with acids like HCl to determine purity or to prepare buffers.

Reaction Planning:
The amount of diethylamine present (0.24 mol) provides a basis for stoichiometric calculations in planned synthesis pathways, ensuring correct reagent ratios.

Environmental and Safety Considerations:
Handling of such solutions must consider the environmental impact, proper disposal methods, and safety protocols due to the compound’s volatility and irritant nature.

Conclusion: Broader Context and Future Perspectives

The scenario of a graduate student receiving 300 mL of 0.80 M diethylamine solution exemplifies fundamental principles in solution chemistry, including molarity calculations, reactivity assessment, and application planning. Diethylamine's broad utility across research fields underlines its importance, but also necessitates a thorough understanding of its properties and behaviors.

Future research may focus on developing safer, more sustainable synthesis methods, exploring novel derivatives, or applying diethylamine in innovative areas such as green chemistry or nanotechnology. As with all chemical reagents, responsible handling and comprehensive understanding remain paramount to harness its full potential.

In sum, diethylamine is more than just a simple secondary amine; it is a key player in modern chemistry with diverse applications and significant scientific relevance. The detailed analysis of its solution concentration, properties, and reactivity provides a foundation for successful research endeavors and safe laboratory practices.

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