A Solution Made By Adding 1.63 G Of K2S (MM=110.3 G/mol) To 10.0 ML Of H2O Has A Volume At 20oC Of 11.1

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Creating solutions in chemistry involves precise measurements and understanding how different substances interact. In this case, we examine the process of dissolving 1.63 grams of potassium sulfide (K_2S) into 10.0 milliliters of water at 20°C, resulting in a solution with a final volume of 11.1 milliliters. This comprehensive guide explores the chemistry behind this process, the calculations involved, and the significance of these measurements in scientific and industrial contexts.

Understanding the Components of the Solution

Before delving into the specifics, it's crucial to understand the properties of the substances involved.

Potassium Sulfide (K_2S)

- **Chemical Formula:** K_2S
- **Molecular Weight (MM):** 110.3 g/mol
- **Physical State:** Typically a yellowish solid at room temperature
- **Uses:** Used in chemical synthesis, as a reagent, and in industrial applications such as pulp and paper processing

Water (H_2O)

- **Physical State:** Liquid at room temperature
- **Density at 20°C:** approximately 0.998 g/mL
- **Properties:** Universal solvent, essential in chemical reactions and solutions

Calculating the Number of Moles of K_2S Added

A fundamental step in understanding the solution's chemistry is calculating how many moles of K_2S are present in 1.63 grams.

Step-by-Step Calculation

1. **Given Data:**
    - Mass of K_2S = 1.63 g
    - MM of K_2S = 110.3 g/mol
2. **Number of moles (n):** Calculated as:

    $n = mass / MM$
3. **Calculation:**

    $n = 1.63 \text{ g} / 110.3 \text{ g/mol} \approx 0.01478 \text{ mol}$

This calculation reveals that approximately 0.01478 moles of K_2S are introduced into the solution.

Understanding the Initial and Final Volumes

The initial volume of water is 10.0 mL. After adding K_2S, the total volume becomes 11.1 mL at 20°C, indicating a volume increase due to dissolution.

Why Does the Volume Change?

- When solids dissolve, the solution’s volume can change depending on interactions at the molecular level
- K_2S dissociates into potassium (K^+) and sulfide (S^{2-}) ions, which interact with water molecules
- The volume increase from 10.0 mL to 11.1 mL reflects both the volume occupied by the dissolved ions and the potential volume expansion due to solvation dynamics

Calculating the Concentration of the Solution

The molarity (M) of the solution indicates the moles of solute per liter of solution.

Steps to Calculate Molarity

1. **Convert the final volume to liters:** 11.1 mL = 0.0111 L
2. **Use the number of moles of K_2S:** 0.01478 mol
3. **Calculate molarity:**

   M = moles / volume in liters = 0.01478 mol / 0.0111 L ≈ 1.33 M

This indicates the solution has a concentration of approximately 1.33 molar (M).

Implications of the Solution Properties

Understanding the concentration and volume changes allows chemists to predict how the solution will behave in various reactions and applications.

Key Points to Consider

- The increased volume affects concentration calculations, which are vital for stoichiometric reactions
- The dissociation of K_2S into ions influences the solution's conductivity and reactivity
- Accurate measurements ensure reproducibility in laboratory experiments and industrial processes

Significance in Scientific and Industrial Contexts

The precise preparation and understanding of such solutions are critical in numerous fields.

Applications of K_2S Solutions

1. **Chemical Synthesis:** Used as a reagent in synthesizing other sulfur-containing compounds
2. **Water Treatment:** Employed to precipitate heavy metals and remove impurities
3. **Industrial Processes:** Used in pulp bleaching and in manufacturing processes involving sulfur compounds

Importance of Accurate Measurements

- Ensures the desired chemical reactions occur with expected yields
- Facilitates safety in handling reactive chemicals like K_2S
- Supports quality control in manufacturing and research environments

Conclusion

In summary, preparing a solution by dissolving 1.63 grams of potassium sulfide (K_2S) into 10.0 mL of water at 20°C results in a solution with a final volume of 11.1 mL and a molarity of approximately 1.33 M. This process involves careful calculations of moles, volume, and concentration, all of which are essential for accurate scientific experimentation and industrial applications. Understanding these principles ensures effective and safe use of chemicals, facilitates proper reaction planning, and underpins innovations across chemistry-related fields.

Additional Tips for Chemists

1. **Always verify measurements:** Use calibrated instruments for weighing and volume measurement
2. **Account for temperature effects:** Volume and density can vary with temperature; 20°C is standard for many calculations
3. **Understand solvation dynamics:** Recognize how ions interact with water molecules, influencing volume and reactivity
4. **Document all steps:** Precise record-keeping ensures reproducibility and facilitates troubleshooting

5. **Use appropriate safety measures:** Handle K_2S with gloves and eye protection, as it can react with moisture to release toxic gases

This comprehensive overview provides a detailed understanding of the process involved in creating and analyzing a potassium sulfide solution, emphasizing the importance of precise measurements and calculations in chemistry.

Frequently Asked Questions

What is the purpose of adding 1.63 g of K_2S to 10.0 mL of water?

Adding K_2S to water creates an aqueous solution of potassium sulfide, which can be used in various chemical applications such as reducing agents, pH adjustment, or in synthesis reactions.

How do you calculate the molarity of the K_2S solution after mixing?

First, convert the mass of K_2S to moles: 1.63 g ÷ 110.3 g/mol ≈ 0.01477 mol. Then, determine the total volume in liters: 11.1 mL = 0.0111 L. Molarity = moles ÷ volume in liters ≈ 0.01477 mol ÷ 0.0111 L ≈ 1.33 M.

Why does the volume of the solution increase to 11.1 mL after adding K_2S?

The volume increase is due to the dissolution of K_2S in water, which causes the mixture to occupy more volume because of solvation and interactions between water molecules and dissolved ions.

What is the significance of the molar mass (110.3 g/mol) of K_2S in preparing the solution?

The molar mass allows for precise calculation of the number of moles of K_2S added, ensuring accurate concentration and reproducibility of the solution.

At 20°C, how does temperature affect the volume of the K_2S solution?

Temperature influences the volume because of thermal expansion; at 20°C, the solution's volume is stable, but increasing temperature could slightly expand the solution, altering volume measurements.

Can this solution be used for reactions requiring a specific

molarity of K_2S?

Yes, by calculating the molarity as shown, this solution can be used in reactions that require approximately 1.33 M K_2S, provided the volume and concentration are accurately maintained.

What safety precautions should be taken when preparing a K_2S solution?

K_2S is a hazardous chemical that can release toxic hydrogen sulfide gas upon contact with acids or moisture. Use proper personal protective equipment, work in a well-ventilated area, and handle with care.

How does the addition of K_2S affect the pH of the water solution?

Potassium sulfide is a salt of a weak acid and a strong base, so it tends to produce a basic solution, increasing the pH of the water upon dissolution.

Additional Resources

In-Depth Analysis of the Solution Formation: Adding 1.63 g of K_2S to 10.0 mL of Water at 20°C

Introduction

Understanding the formation of solutions through the addition of solutes to solvents is fundamental in chemistry, especially in solution chemistry and thermodynamics. The specific case of adding 1.63 grams of potassium sulfide (K_2S) to 10.0 mL of water at 20°C, resulting in a solution volume of approximately 11.1 mL, offers insights into various physicochemical principles. This detailed review explores the process from multiple angles, including molar calculations, volumetric changes, concentration determinations, and thermodynamic considerations.

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1. Composition and Properties of the Solute: Potassium Sulfide (K_2S)

Molecular Details

- Molecular weight (MM): 110.3 g/mol
- Chemical formula: K_2S
- Constituents:
- Potassium (K): atomic weight ≈ 39.1 g/mol
- Sulfur (S): atomic weight ≈ 32.07 g/mol

Physical and Chemical Characteristics

- Solubility in water: Potassium sulfide is highly soluble, forming aqueous solutions readily.

- Dissociation in water:

$$
\text{K}_2\text{S} \rightarrow 2\text{K}^+ + \text{S}^{2-}
$$

- Applications: Used in chemical synthesis, as a reducing agent, and in various industrial processes.

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2. Quantitative Analysis: Moles of K_2S Added

Calculating the moles allows for understanding molarity, solution strength, and potential chemical reactions.

Step 1: Moles of K_2S

$$
\text{Moles of K}_2\text{S} = \frac{\text{Mass of K}_2\text{S}}{\text{MM}} = \frac{1.63\, \text{g}}{110.3\, \text{g/mol}} \approx 0.01477\, \text{mol}
$$

This small quantity indicates a dilute solution, suitable for many laboratory applications.

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3. Volume Considerations: From Water to Solution

Initial Volume of Water

- Given: 10.0 mL at 20°C
- Density of water at 20°C: approximately 0.998 g/mL

Mass of Water

$$
\text{Mass of water} = \text{Density} \times \text{Volume} = 0.998\, \text{g/mL} \times 10.0\, \text{mL} \approx 9.98\, \text{g}
$$

Total mass before dissolution

$$
\text{Total mass} = 9.98\, \text{g} + 1.63\, \text{g} = 11.61\, \text{g}
$$

---

4. Volume Change Upon Dissolution: The 11.1 mL Final Volume

Observed Volume

- Final volume after dissolution: 11.1 mL at 20°C
- Volume increase: approximately 1.1 mL

This indicates that dissolution of K_2S causes a volume expansion, which is typical due to several factors:

- Volume contraction/expansion upon solvation depending on solute-solvent interactions
- Ion hydration shells forming around K^+ and S^{2-} ions
- Partial packing of water molecules being disrupted, leading to volume changes

Significance

Although the initial and final volumes are close, the increase suggests that K_2S dissolves in water with some volume expansion, which can influence concentration calculations.

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5. Concentration Analysis: Molarity and Ionic Strength

Molarity (M)

$$
\text{Concentration} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}}
$$

Since the volume after dissolution is approximately 11.1 mL = 0.0111 L:

$$
\text{Molarity} = \frac{0.01477\, \text{mol}}{0.0111\, \text{L}} \approx 1.33\, \text{M}
$$

This indicates a roughly 1.33 molar solution of K_2S, which is relatively concentrated.

Ionic Strength

Ionic strength (I) is a measure of the total concentration of ions in solution, weighted by their charges:

$$
I = \frac{1}{2} \sum c_i z_i^2
$$

- Concentrations of ions:

$$
\text{K}^+:\quad 2 \times 0.01477\, \text{mol} = 0.02954\, \text{mol}
$$

$$
\text{S}^{2-}:\quad 0.01477\, \text{mol}
$$

- Concentrations in the final volume:

$$
[\text{K}^+] = \frac{0.02954\, \text{mol}}{0.0111\, \text{L}} \approx 2.66\, \text{M}
$$

$$
[\text{S}^{2-}] = \frac{0.01477\, \text{mol}}{0.0111\, \text{L}} \approx 1.33\, \text{M}
$$

- Calculate ionic strength:

$$
I = \frac{1}{2} \left([\text{K}^+]\times (z_{K^+})^2 + [\text{S}^{2-}]\times (z_{S^{2-}})^2 \right)
$$

$$
I = \frac{1}{2} \left(2.66 \times 1^2 + 1.33 \times 2^2 \right) = \frac{1}{2} (2.66 + 1.33 \times 4) = \frac{1}{2} (2.66 + 5.32) = \frac{1}{2} (7.98) \approx 3.99\, \text{M}
$$

This high ionic strength indicates significant ion interactions, which influence various properties like activity coefficients and reactivity.

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6. Thermodynamic and Physical Properties

Dissolution Process

- The dissolution of K_2S in water is exothermic, releasing energy owing to hydration enthalpy.
- The volume expansion suggests that the process involves both solvation energy and physical volume changes.

Impact of Temperature

- At 20°C, water's properties are well-characterized, but temperature shifts can alter solubility, volume, and density.
- Thermal expansion and solubility changes are important for precise applications.

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7. Practical Implications and Applications

Laboratory Use

- Preparing solutions of known molarity is critical for titrations, calibrations, and reactions.
- Recognizing volume expansion helps in calculating accurate concentrations.

Industrial and Chemical Reactions

- High ionic strength solutions like this are used in electrochemistry, materials synthesis, and chemical analysis.
- Understanding the solution's properties guides process optimization.

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8. Additional Considerations

Solvation and Ion Pairing

- At high concentrations, ion pairing may occur, slightly reducing effective ionic activity.
- Hydration shells influence solution stability and reactivity.

Precautions

- Handling K_2S requires care due to its corrosiveness and potential to release hydrogen sulfide gas upon decomposition or contact with acids.

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9. Summary and Conclusions

This analysis of adding 1.63 g of K_2S to 10.0 mL of water at 20°C reveals several key insights:

- The molar amount of K_2S is approximately 0.01477 mol.
- The final solution volume increases slightly to 11.1 mL, indicating volume expansion upon dissolution.
- The resulting solution exhibits a molarity of roughly 1.33 M for K_2S, with ionic concentrations reaching approximately 2.66 M for K^+ and 1.33 M for S^{2-}.
- The ionic strength is high (~4.0 M), affecting activity coefficients and solution behavior.
- The physical process involves volume expansion due to hydration and solvation effects, with thermodynamic considerations indicating an exothermic dissolution process.

Understanding these aspects provides a comprehensive picture of the solution's properties, essential for both theoretical and practical applications in chemistry.

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10. Final Remarks

This detailed examination underscores how the interplay of molar calculations, volumetric changes, ionic interactions, and thermodynamics shapes the behavior of solutions. Such insights are fundamental for chemists designing experiments, scaling industrial processes, or studying solution dynamics. Recognizing the nuances in solution formation, especially involving electrolytes like K_2S, enhances our ability to manipulate and utilize chemical systems effectively.

Note: The calculations assume ideal behavior and neglect minor effects such as activity coefficients or deviations from ideality

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