25 Gram Saturated Solution Of Potassium Nitrate At 95 C Is Cooled Down To 55 C Then How Much Gram Of

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Understanding the behavior of potassium nitrate (KNO_3) in solution is essential for various applications in chemistry, agriculture, and industrial processes. When a saturated solution is cooled, the solubility of the salt decreases, leading to crystallization or precipitation of the excess solute. This article delves into the detailed calculation of how much potassium nitrate crystallizes out when a 25-gram saturated solution at 95°C is cooled down to 55°C. By exploring the principles of solubility, saturation, and crystallization, we aim to provide a comprehensive understanding that benefits students, educators, and professionals alike.

Introduction to Saturated Solutions and Solubility

A saturated solution contains the maximum amount of dissolved solute at a specific temperature. For potassium nitrate, solubility varies significantly with temperature, which means that the amount of KNO_3 that can dissolve in water at different temperatures changes accordingly.

Key points:

- Solubility of KNO_3 at various temperatures:
- At 25°C: approximately 32 g per 100 mL of water
- At 55°C: approximately 62 g per 100 mL of water
- At 95°C: approximately 111 g per 100 mL of water

- Implication:
As temperature increases, more potassium nitrate dissolves in water; conversely, cooling causes some of the dissolved KNO_3 to crystallize out.

Understanding the Problem Statement

The problem involves a saturated solution of potassium nitrate at 95°C, with a total mass of 25 grams. This solution is then cooled to 55°C, and the question asks:

"How much potassium nitrate crystallizes out during this cooling?"

To solve this, we need to:

1. Find the amount of KNO_3 dissolved at 95°C in the initial saturated solution.
2. Determine the maximum amount of KNO_3 that can remain dissolved at 55°C.
3. Calculate the difference to find out how much crystallizes out during cooling.

Step-by-Step Solution Approach

1. Determine the initial composition at 95°C

Since the solution is saturated at 95°C:

- The solubility of KNO_3 at 95°C ≈ 111 g per 100 mL of water.

- Total solution mass = 25 g.

- To find how much of this is KNO_3 and how much is water, assumptions are made:

- The solution consists of water + dissolved KNO_3.

- Let’s denote:

- m_{water} = mass of water in the solution

- m_{KNO_3} = mass of potassium nitrate in the solution

- Since the solution is saturated at 95°C:

$$
\frac{m_{KNO_3}}{m_{water}} = \frac{111\,g}{100\,mL}
$$

- The density of water is approximately 1 g/mL, so:

$$
100\,mL \approx 100\,g
$$

- Therefore, the ratio simplifies to:

$$
\frac{m_{KNO_3}}{m_{water}} = \frac{111\,g}{100\,g}
$$

- Total mass:

$$
m_{total} = m_{KNO_3} + m_{water} = 25\,g
$$

- Express m_{KNO_3} in terms of m_{water}:

$$
m_{KNO_3} = \frac{111}{100} \times m_{water}
$$

- Total mass:

$$
m_{KNO_3} + m_{water} = 25\,g
$$

$$
\frac{111}{100} \times m_{water} + m_{water} = 25
$$

$$
\left(\frac{111}{100} + 1 \right) m_{water} = 25
$$

$$
\frac{211}{100} m_{water} = 25
$$

$$
m_{water} = \frac{25 \times 100}{211} \approx 11.84\,g
$$

- Now, find m_{KNO_3}:

$$
m_{KNO_3} = \frac{111}{100} \times 11.84 \approx 13.15\,g
$$

Therefore, at 95°C:

- Water = approximately 11.84 g
- KNO_3 = approximately 13.15 g

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2. Determine the maximum solubility at 55°C

- Solubility of KNO_3 at 55°C ≈ 62 g per 100 mL of water.

- Using the same approach:

$$
m_{KNO_3, max} = \frac{62}{100} \times m_{water}
$$

- Since the water remains the same (initially), the maximum amount of KNO_3 that can stay dissolved at 55°C is:

$$
m_{KNO_3, max} = 0.62 \times 11.84 \approx 7.34\,g
$$

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3. Calculate the amount of potassium nitrate crystallized out

- Initial amount of KNO_3 in the saturated solution at 95°C: approximately 13.15 g

- Maximum dissolved at 55°C: approximately 7.34 g

- Crystallized out:

$$
13.15\,g - 7.34\,g \approx 5.81\,g
$$

Result: About 5.81 grams of potassium nitrate crystallizes out when the solution is cooled from 95°C to 55°C.

Implications and Practical Considerations

Understanding the crystallization process during cooling has significant practical applications:

- Purification of KNO_3: Crystallization helps in purifying potassium nitrate by removing impurities that do not crystallize.

- Industrial crystallization processes: Control of temperature and saturation levels enables efficient recovery of KNO_3.

- Agricultural applications: Precise knowledge of solubility aids in preparing solutions for fertilization.

Factors affecting crystallization:

- Rate of cooling: Rapid cooling may lead to smaller crystals, while slow cooling favors larger crystals.

- Presence of impurities: Impurities can either inhibit or promote crystallization.

- Stirring and seed crystals: These influence nucleation and crystal growth.

Additional Considerations in Solubility Calculations

While the above calculations provide a close approximation, real-world scenarios may involve:

- Slight variations in solubility data based on the purity of chemicals and measurement conditions.

- The assumption that the water volume remains constant upon cooling, which may not always be valid.

- The potential for some KNO_3 to remain dissolved beyond the typical solubility limits due to supercooling effects.

Therefore, for precise industrial applications, empirical data and laboratory measurements should complement theoretical calculations.

Conclusion

To summarize:

- A 25-gram saturated solution of potassium nitrate at 95°C contains approximately 13.15 grams of KNO_3 dissolved in about 11.84 grams of water.

- When cooled to 55°C, the maximum solubility drops to approximately 7.34 grams of KNO_3.

- Consequently, about 5.81 grams of potassium nitrate crystallizes out during this cooling process.

Understanding these principles is crucial for optimizing processes involving potassium nitrate solutions, whether in chemical manufacturing, agriculture, or research.

SEO Keywords and Phrases

- Potassium nitrate solubility at different temperatures
- Crystallization of KNO_3 during cooling
- Saturated potassium nitrate solution calculation

- How much KNO_3 crystallizes out when cooled
- Solubility of potassium nitrate at 95°C and 55°C
- KNO_3 crystallization process
- Industrial applications of potassium nitrate crystallization
- Properties of saturated solutions in chemistry

By mastering the concepts of solubility and crystallization, students and professionals can effectively manipulate solutions for various scientific and industrial purposes.

Frequently Asked Questions

How much potassium nitrate crystallizes out when a 25 g saturated solution at 95°C is cooled to 55°C?

Approximately 15.6 grams of potassium nitrate crystallizes out during cooling from 95°C to 55°C.

What is the amount of potassium nitrate remaining in solution after cooling the saturated solution from 95°C to 55°C?

About 9.4 grams of potassium nitrate remains dissolved in the solution after cooling.

How do you calculate the amount of potassium nitrate crystallized upon cooling a saturated solution?

Subtract the amount of potassium nitrate dissolved at the lower temperature (55°C) from the initial amount at 95°C; the difference is the crystallized amount.

Why does potassium nitrate crystallize out when the saturated solution is cooled from 95°C to 55°C?

Because the solubility of potassium nitrate decreases with temperature, causing excess solute to crystallize out of the solution.

What is the significance of solubility curves in solving this problem?

Solubility curves help determine how much potassium nitrate can stay dissolved at different temperatures, allowing calculation of crystallized amounts during cooling.

If the initial saturated solution contains 25 g of potassium

nitrate at 95°C, how much remains dissolved at 55°C?

Approximately 9.4 grams of potassium nitrate remains dissolved at 55°C after cooling.

Additional Resources

Potassium Nitrate Saturation Solution Analysis at Varied Temperatures

In the realm of chemical solutions, understanding the behavior of solutes like potassium nitrate (KNO_3) across temperature ranges is crucial for applications spanning agriculture, food preservation, and chemical manufacturing. This article delves into a specific scenario: a 25-gram saturated solution of potassium nitrate at 95°C being cooled to 55°C. We will explore what happens during this cooling process, how much potassium nitrate remains dissolved, and the factors influencing this behavior. This comprehensive analysis aims to clarify the principles behind solubility, crystallization, and solution dynamics, providing valuable insights for students, professionals, and enthusiasts alike.

Understanding Saturated Solutions and Solubility

Before addressing the specifics of the scenario, it's essential to grasp the foundational concepts:

What Is a Saturated Solution?

A saturated solution contains the maximum amount of solute (here, potassium nitrate) that can dissolve in a solvent (water) at a particular temperature. Any additional solute will remain undissolved, often forming crystals or precipitates.

Solubility and Temperature Dependence

The solubility of potassium nitrate is notably temperature-dependent. Typically, as temperature increases, solubility also increases, allowing more salt to dissolve. Conversely, cooling reduces solubility, potentially causing some dissolved salt to crystallize out of the solution.

Temperature (°C)	Solubility of KNO_3 (grams per 100 mL water)
95	approximately 246 g/100 mL
55	approximately 136 g/100 mL

Note: These values are approximate and based on standard solubility data.

Initial Conditions: 25 Grams of Saturated Solution at 95°C

In this specific case, we begin with:

- Solution mass: 25 grams
- Temperature: 95°C
- Nature of solution: Saturated at 95°C

Given the high temperature, the solution contains a significant amount of potassium nitrate, close to its maximum solubility at 95°C. To understand the amount of KNO_3 dissolved, let's analyze the composition based on solubility data.

Calculating the Amount of Dissolved KNO_3 at 95°C

Since the solubility at 95°C is approximately 246 g of KNO_3 per 100 mL of water, we can determine the dissolved salt for a given solution:

- Assume the total solution is 25 grams, primarily water with some KNO_3.
- The challenge is that the total mass includes both water and dissolved salt, but the solubility data is per unit volume of water, not total solution.

Step 1: Approximate the volume of water in the solution

Given the high solubility, most of the solution is water with some dissolved KNO_3.

Suppose:

- Let x be the mass of water (grams).
- Let y be the mass of dissolved KNO_3 (grams).

Because the solution is saturated at 95°C:

- y ≈ (solubility at 95°C) (volume of water in liters)

But since we are working with grams and no direct volume, a common approach is to assume the solution is mostly water, and the total mass is:

$$ x + y = 25\, \text{grams} $$

Given the solubility:

$$ y \approx 2.46\, \text{g per gram water} $$

because 246 g per 100 mL (which roughly corresponds to 100 g, assuming density ~1 g/mL), so:

$$ \text{Mass of salt} = 2.46 \times \text{mass of water (grams)} $$

Step 2: Establish the relationship

$$ y = 2.46 \times x $$

And total mass:

$$ x + y = 25 $$

Substitute:

$$ x + 2.46x = 25 $$

$$ 3.46x = 25 $$

$$ x \approx \frac{25}{3.46} \approx 7.22\, \text{grams} $$

Then,

$$ y = 2.46 \times 7.22 \approx 17.78\, \text{grams} $$

Result:

- Water: approximately 7.22 grams
- Potassium nitrate dissolved: approximately 17.78 grams

Note: This is an approximation assuming ideal conditions and that the solution is saturated at 95°C.

Cooling the Solution from 95°C to 55°C

The core of this analysis involves understanding what happens when the saturated solution at 95°C cools down to 55°C.

Changes in Solubility with Temperature

As the temperature drops from 95°C to 55°C:

- The solubility of potassium nitrate decreases from approximately 246 g/100 mL to 136 g/100 mL.
- This reduction means that less potassium nitrate can remain dissolved at the lower temperature.

Implication for the Solution

Since the initial solution contains roughly 17.78 grams of dissolved KNO_3, and the solubility at 55°C is about 136 g/100 mL, the solution is:

- Less saturated at 55°C than at 95°C, because the maximum dissolving capacity is lower.
- The dissolved amount (17.78 g) is well below the new saturation limit (136 g/100 mL), indicating that no additional crystals will form during cooling under ideal conditions.

However, real-world factors such as nucleation sites, agitation, and cooling rate can induce crystallization even if the solution is undersaturated in theory.

How Much Potassium Nitrate Crystallizes During Cooling?

Since the solution at 95°C was saturated with approximately 17.78 grams of KNO_3, and the solubility at 55°C is higher than this amount, the solution remains unsaturated at the lower temperature. Therefore, no crystallization should occur during cooling if the solution remains undisturbed and no nucleation sites are introduced.

But in practical settings, the process often involves:

- Supercooling: The solution cools below its saturation point without crystallizing.
- Nucleation and Crystallization: Once nucleation starts, excess KNO_3 precipitates out to reach the new equilibrium solubility limit.

Assuming ideal conditions:

- The dissolved amount remains approximately the same (~17.78 grams).
- No additional crystallization occurs because the solution is undersaturated at 55°C.

In a real-world scenario, if the solution was initially supersaturated (containing more than the equilibrium amount for 55°C), then the excess KNO_3 would crystallize out.

Estimating Crystallization if the Solution Were Oversaturated

Suppose the initial solution at 95°C was super-saturated—for instance, containing more than 17.78 grams per 25 grams of solution—then upon cooling:

- Excess KNO_3 would crystallize out until the solution reaches the solubility at 55°C (136 g/100 mL).
- The amount crystallized would be the difference between the initial dissolved KNO_3 and the maximum soluble at 55°C.

Calculating the amount crystallized:

- Initial dissolved KNO_3: approximately 17.78 grams
- Max soluble at 55°C: 136 g per 100 mL

From earlier, the approximate volume of water is 7.22 grams, which corresponds to:

$$\text{Volume} = \frac{7.22\, \text{g}}{\text{density of water} \approx 1\, \text{g/mL}} \approx 7.22\, \text{mL}$$

In 7.22 mL of water:

$$\text{Max solubility} = 136\, \text{g/100 mL} \times 7.22\, \text{mL} \approx 9.82\, \text{g}$$

This indicates that at 55°C, roughly 9.82 grams of KNO_3 can remain dissolved in the water present.

Thus:

- If the initial dissolved amount (~17.78 g) exceeds 9.82 g, then:

$$\text{Crystallized amount} = 17.78\, \text{g} - 9.82\, \text{g} \approx 7.96\, \text{g}$$

This is the amount of potassium nitrate that would crystallize out during the cooling process, assuming super-saturation.

Summary of Key Findings

Scenario	Dissolved KNO_3 (grams)	Crystallized KNO_3 (grams)	Remarks
Ideal cooling (no super-saturation)	remains approximately 17.78 g	0 g	No crystallization expected if solution is initially saturated at 95°C and cooled slowly.
Super-saturated initial solution	initial >17.78 g (e.g.,

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