A 0.5 M Solution Of ____ Has A PH Of 7.0.a) KF B) KNO3 C) K2S D) NaF E) NH4Br

A 0.5 M Solution Of ____ Has A PH Of 7.0.a) KF B) KNO3 C) K2S D) NaF E) NH4Br is a question that often appears in chemistry discussions, particularly when exploring the concepts of acidity, basicity, and neutrality in aqueous solutions. Understanding why certain salts produce neutral solutions at specific concentrations requires a solid grasp of the nature of their constituent ions, their interactions with water, and the principles of hydrolysis. In this article, we will analyze each of the options provided, discuss their chemical properties, and determine which salt, when dissolved at 0.5 M, results in a solution with a pH of exactly 7.0.

Understanding pH and Salt Solutions

What Is pH?

pH is a measure of the hydrogen ion concentration in a solution. It is expressed on a logarithmic scale:

- pH < 7 indicates acidity
- pH = 7 indicates neutrality
- pH > 7 indicates alkalinity (basicity)

The pH of a solution depends on the nature of its dissolved substances, especially the ions that result from dissolving salts.

Salts and Their Hydrolysis Behavior

Salts are ionic compounds formed from the neutralization of an acid and a base. When dissolved in water, salts dissociate into their constituent ions. These ions can influence the pH of the solution through hydrolysis:

- Neutral ions (from strong acids and strong bases) typically do not affect pH
- Acidic ions (from weak bases or strong acids) can lower pH
- Basic ions (from weak acids or strong bases) can raise pH

Understanding whether an ion hydrolyzes (reacts with water) is crucial in predicting the pH of the resulting solution.

Analysis of the Given Options

a) KF (Potassium fluoride)

KF is formed from potassium hydroxide (a strong base) and hydrofluoric acid (a weak acid). When dissolved:

- K^+ ions are from a strong base (KOH), typically inert and do not hydrolyze
- F^- ions are from a weak acid (HF), which can hydrolyze to produce OH^- ions

Since F^- can hydrolyze and produce hydroxide ions, solutions of KF tend to be slightly basic, resulting in pH values above 7. Therefore, KF solutions are not neutral at 0.5 M; they are slightly basic.

b) KNO_3 (Potassium nitrate)

KNO_3 results from a strong base (KOH) and a strong acid (HNO_3). Dissolving KNO_3:

- Produces K^+ and NO_3^- ions, both of which are inert in water

Because neither ion hydrolyzes or alters the pH, solutions of KNO_3 are neutral, with a pH close to 7. At 0.5 M concentration, KNO_3 solutions are typically neutral, making this a strong candidate.

c) K_2S (Potassium sulfide)

K_2S is derived from KOH (a strong base) and H_2S (a weak acid). When dissolved:

- K^+ ions are inert
- S^{2-} ions are from H_2S, a weak acid, but S^{2-} is a very strong base and readily hydrolyzes

S^{2-} ions tend to produce hydroxide ions upon hydrolysis, making solutions basic. Thus, K_2S solutions are not neutral; they are basic.

d) NaF (Sodium fluoride)

NaF is similar to KF; it results from a strong base (NaOH) and a weak acid (HF). When dissolved:

- Na^+ is inert
- F^- can hydrolyze to produce OH^-, making the solution slightly basic

Therefore, NaF solutions are not neutral but slightly basic, especially at higher concentrations.

e) NH_4Br (Ammonium bromide)

NH_4Br results from a weak acid (HBr, a strong acid, but in this case, HBr is strong, so NH_4^+ is from a weak acid) and a strong acid (HBr). More specifically:

- NH_4^+ is the conjugate acid of a weak base (NH_3), which can hydrolyze to produce H^+ ions
- Br^- is from a strong acid (HBr), inert in water

Hydrolysis of NH_4^+ releases H^+ ions, making the solution slightly acidic. Therefore, solutions of NH_4Br are acidic, not neutral.

Conclusion: Which Salt Produces a Neutral 0.5 M Solution?

Based on the analysis:

- KF: Slightly basic
- KNO_3: Neutral
- K_2S: Basic
- NaF: Slightly basic
- NH_4Br: Acidic

The salt that, when dissolved at 0.5 M, yields a solution with a pH of approximately 7.0 is KNO_3 because it results from the combination of a strong acid and a strong base, both of which dissociate completely and do not hydrolyze.

Additional Considerations and Practical Aspects

Concentration Effects on pH

While the analysis predicts that KNO_3 produces a neutral solution, it's important to note that at very high concentrations, minor deviations may occur due to ion interactions or impurities. However, at typical laboratory concentrations such as 0.5 M, the solution remains effectively neutral.

Experimental Verification

To confirm the theoretical prediction:

1. Dissolve 0.5 moles of KNO_3 in 1 liter of distilled water
2. Measure the pH using a calibrated pH meter
3. Observe that the pH is approximately 7.0, confirming neutrality

Summary

Understanding the hydrolysis behavior of ions in solution is key to predicting the pH of salt solutions. In the case of the options provided, potassium nitrate (KNO_3) stands out as the salt that produces a neutral solution at 0.5 M concentration, with a pH close to 7.0. This is because both K^+ and NO_3^- ions originate from strong acids and bases, ensuring no hydrolysis occurs to alter the pH significantly.

Final Remarks

This analysis highlights the importance of considering the origin and hydrolysis tendencies of ions when predicting the pH of salt solutions. Recognizing these principles is essential in fields ranging from analytical chemistry to environmental science, where controlling and understanding solution pH is fundamental.

If you have further questions about specific salts or the principles of hydrolysis, consulting detailed chemistry textbooks or laboratory resources is highly recommended.

Frequently Asked Questions

Which compound among KF, KNO3, K2S, NaF, and NH4Br, when dissolved in water at 0.5 M, results in a pH of exactly 7.0?

KNO3

Why does a 0.5 M KNO3 solution have a pH of 7.0?

Because KNO3 is a neutral salt formed from a strong acid (HNO3) and a strong base (KOH), which do not affect the pH of the solution.

Which of the listed compounds are salts that produce neutral solutions in water?

KF and KNO3 are neutral salts that produce pH 7.0 in solution.

What is the significance of a solution with pH 7.0 in terms of acidity

and basicity?

A pH of 7.0 indicates a neutral solution, meaning it is neither acidic nor basic.

Among the options, which compound is likely to produce a basic solution in water?

K_2S, because S^{2-} is a weak base and can slightly increase the pH.

How does the nature of the salt determine the pH of its aqueous solution?

The pH depends on whether the salt is formed from strong or weak acids and bases; neutral salts from strong acid and base produce pH 7.0, while salts from weak acids or bases can produce acidic or basic solutions.

Is NaF a neutral, acidic, or basic salt in solution?

NaF is a basic salt because F^- is the conjugate base of a weak acid (HF), which can hydrolyze and increase pH.

What role does hydrolysis play in determining the pH of a salt solution?

Hydrolysis of the ions in solution can either produce H^+ or OH^- ions, affecting whether the solution is acidic, neutral, or basic.

Why is NH_4Br unlikely to have a pH of 7.0 at 0.5 M concentration?

Because NH_4^+ is the conjugate acid of a weak base (NH_3), it tends to hydrolyze and make the solution slightly acidic, resulting in a pH below 7.

Based on the options, which salts are most likely to produce pH 7.0 solutions at 0.5 M concentration?

KNO_3 and KF, as they originate from strong acids and strong bases, are most likely to produce neutral solutions with pH 7.0.

Additional Resources

Understanding the pH of a 0.5 M Solution of Various Potassium Salts: An In-Depth Analysis

The behavior of solutions in aqueous media, particularly their pH, hinges critically on the nature of the solutes—specifically, the salts dissolved. When examining a 0.5 M solution of different potassium salts, the key question often posed is: What determines whether the solution is neutral, acidic, or basic? In this review, we explore why a 0.5 M solution of certain potassium salts exhibits a pH of exactly 7.0, and delve deep into the underlying chemical principles, including hydrolysis, salt origin, and the properties of constituent ions.

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1. The Significance of pH in Salt Solutions

pH measures the hydrogen ion concentration in a solution. Pure water has a neutral pH of 7.0 at 25°C. When salts dissolve, their dissociation products can influence the pH, leading to acidic, neutral, or basic solutions.

- Neutral solutions generally result from salts derived from a strong acid and a strong base.
- Acidic solutions arise when the salt comes from a strong acid and a weak base.
- Basic solutions are typically from salts formed from a weak acid and a strong base.

Understanding which category each salt falls into is crucial for predicting the pH of their aqueous solutions.

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2. The Role of Hydrolysis and Ion Nature

The pH of a salt solution depends on whether its constituent ions undergo hydrolysis in water:

- Hydrolysis is the reaction of an ion with water, leading to the formation of either H_3O^+ (hydronium) or OH^- (hydroxide).
- Ions from strong acids and strong bases (e.g., K^+ and Cl^-) do not hydrolyze, resulting in a neutral solution.
- Ions from weak acids or weak bases can hydrolyze, thus affecting pH.

In essence, the pH of the solution hinges on the acid-base properties of the ions resulting from salt dissociation.

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3. Analyzing Each Salt: Composition and Hydrolysis

Let's analyze each potassium salt listed, considering their constituent ions and hydrolysis tendencies.

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a) KF (Potassium Fluoride)

- Dissociation:

\[
\mathrm{KF} \rightarrow \mathrm{K}^+ + \mathrm{F}^-

\]

- Ion Characteristics:
- K^+: from a strong base (KOH), does not hydrolyze.
- F^-: from a weak acid (HF), can hydrolyze.

- Hydrolysis of F^-:

\[
\mathrm{F}^- + \mathrm{H_2O} \rightleftharpoons \mathrm{HF} + \mathrm{OH}^-
\]

Since F^- is the conjugate base of a weak acid, it tends to accept a proton, generating hydroxide ions, making the solution slightly basic.

- Expected pH:

- The solution of KF is slightly basic due to hydrolysis of F^-, which increases pH above 7.0.

- Conclusion:

- A 0.5 M KF solution would have pH greater than 7.0, so it does not match the given condition.

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b) KNO_3 (Potassium Nitrate)

- Dissociation:

\[
\mathrm{KNO}_3 \rightarrow \mathrm{K}^+ + \mathrm{NO}_3^-

\]

- Ion Characteristics:
- K^+: from a strong base, does not hydrolyze.
- NO_3^-: from a strong acid (HNO_3), does not hydrolyze.

- Hydrolysis:

Neither ion hydrolyzes; both are from strong acid/base origins.

- Expected pH:

- The solution is neutral at 25°C, with pH approximately 7.0.

- Conclusion:

- A 0.5 M solution of KNO_3 is neutral, matching the given pH of 7.0.

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c) K_2S (Potassium Sulfide)

- Dissociation:

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

- Ion Characteristics:
- K^+: from a strong base, does not hydrolyze.
- S^{2-}: from a weak acid (H_2S), can hydrolyze.

- Hydrolysis of S^{2-}:

$$
\mathrm{S}^{2-} + \mathrm{H_2O} \rightleftharpoons \mathrm{HS}^- + \mathrm{OH}^-
$$

Since S^{2-} is the conjugate base of a weak acid (H_2S), it acts as a base in water, generating hydroxide ions, making the solution basic.

- Expected pH:

- The solution would be basic (pH > 7), not neutral.

- Conclusion:

- A 0.5 M K_2S solution would be basic, so it does not match the pH of 7.0.

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d) NaF (Sodium Fluoride)

- Dissociation:

$$
\mathrm{NaF} \rightarrow \mathrm{Na}^+ + \mathrm{F}^-
$$

- Ion Characteristics:
- Na^+: from a strong base, does not hydrolyze.
- F^-: weak acid conjugate base, hydrolyzes to produce OH^-.

- Hydrolysis:

$$
\mathrm{F}^- + \mathrm{H_2O} \rightleftharpoons \mathrm{HF} + \mathrm{OH}^-
$$

- Expected pH:

- Slightly basic, pH > 7.0.

- Conclusion:

- The solution would be basic, not neutral.

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e) NH_4Br (Ammonium Bromide)

- Dissociation:

$$
\mathrm{NH}_4\mathrm{Br} \rightarrow \mathrm{NH}_4^+ + \mathrm{Br}^-
$$

- Ion Characteristics:
- NH_4^+: from a weak base (NH_3), acts as a weak acid.
- Br^-: from a strong acid (HBr), does not hydrolyze.

- Hydrolysis of NH_4^+:

\[

\mathrm{NH}_4^+ + \mathrm{H_2O} \rightleftharpoons \mathrm{NH}_3 + \mathrm{H_3O}^+

\]

As the conjugate acid of NH_3, NH_4^+ releases H^+, making the solution acidic.

- Expected pH:

- The solution would be acidic, pH less than 7.

- Conclusion:

- NH_4Br would yield a pH below 7, not neutral.

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4. Summarizing the pH Behavior of Each Salt

Salt	Constituent Ions	Hydrolysis Tendency	Expected pH	Matches pH 7.0?
KF	K^+, F^-	F^- hydrolyzes, basic	Slightly basic (>7)	No
KNO_3	K^+, NO_3^-	No hydrolysis	Neutral (~7)	Yes
K_2S	K^+, S^{2-}	S^{2-} hydrolyzes, basic	Basic (>7)	No
NaF	Na^+, F^-	F^- hydrolyzes, basic	Slightly basic (>7)	No
NH_4Br	NH_4^+, Br^-	NH_4^+ hydrolyzes, acidic	Acidic (<7)	No

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5. The Key Finding: Why Is the Solution of KNO_3 Neutral?

Given the above analysis, the only salt whose aqueous solution at 0.5 M concentration results in a pH of exactly 7.0 is KNO_3. This is because:

- Both K^{+} and NO_3^{-} originate from strong acid/base sources.

- Neither ion undergoes hydrolysis, preserving neutrality.

- The solution remains unaffected by hydrolysis reactions, maintaining a pH close to that of pure water.

This neutrality is a fundamental principle of salt chemistry: salts formed from strong acids and strong bases produce neutral solutions.

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6. Additional Factors Influencing p

A 0 5 M Solution Of Has A Ph Of 7 0 A Kf B Kno3 C K2s D Naf E Nh4br

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