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Understanding Acids: Strong vs. Weak

Acids are fundamental substances in chemistry, characterized by their ability to donate protons (H⁺ ions) in aqueous solutions. They play vital roles in various chemical processes, industrial applications, biological functions, and environmental systems. Recognizing the difference between strong and weak acids is essential for students, chemists, and anyone working with chemical substances.

This article explores the characteristics that distinguish strong acids from weak acids, focusing on the specific options provided in the question: HF, HCl, HBr, HNO₃, and HClO₄. By understanding their properties, we can accurately identify which among them is a weak acid.

What Is a Strong Acid?

A strong acid is an acid that completely dissociates into its ions in aqueous solution. This means that when a strong acid dissolves in water, virtually all of the acid molecules release their protons (H⁺ ions), resulting in a high concentration of hydrogen ions and a correspondingly low pH.

Characteristics of Strong Acids

- Complete Dissociation: They dissociate fully in water.
- High Conductivity: Due to high ion concentrations.
- Low pH Values: Usually below 3.
- Examples: Hydrochloric acid (HCl), sulfuric acid (H₂SO₄), nitric acid (HNO₃), hydrobromic acid (HBr), and perchloric acid (HClO₄).

Chemical Behavior

For example, hydrochloric acid (HCl) in water dissociates as:



This dissociation is essentially complete, making HCl a strong acid.

What Is a Weak Acid?

In contrast, a weak acid only partially dissociates in water. This incomplete dissociation results in a lower concentration of hydrogen ions compared to strong acids of similar concentration.

Characteristics of Weak Acids

- Partial Dissociation: Only a fraction of acid molecules release H^+ .
- Lower Conductivity: Due to fewer free ions.
- Higher pH Values: Usually between 3 and 7.
- Equilibrium Established: Between undissociated acid and ions.

Example: Hydrofluoric Acid (HF)

HF is a typical weak acid. It dissociates as:



But the dissociation is not complete, and an equilibrium exists between the undissociated HF and its ions.

Analyzing the Options: Which Is a Weak Acid?

Let's analyze each of the options provided:

1. Hydrofluoric Acid (HF)

- Nature: Weak acid.
- Dissociation: Partially dissociates in water.
- Unique Property: Despite being weak, HF is highly toxic and corrosive.
- Applications: Used in etching glass, industrial cleaning, and organic synthesis.

2. Hydrochloric Acid (HCl)

- Nature: Strong acid.
- Dissociation: Fully dissociates in water.
- Common Use: Laboratory reagent, industrial cleaning, pH control.

3. Hydrobromic Acid (HBr)

- Nature: Strong acid.
- Dissociation: Fully dissociates.
- Uses: Synthesis of bromine compounds, pharmaceuticals.

4. Nitric Acid (HNO_3)

- Nature: Strong acid.
- Dissociation: Complete dissociation.
- Applications: Fertilizers, explosives, etching.

5. Perchloric Acid (HClO₄)

- Nature: Strong acid.
- Dissociation: Fully dissociates.
- Uses: Rocket propellants, laboratory reagent.

Conclusion: Among the options, HF (hydrofluoric acid) is the only weak acid.

Why Is HF a Weak Acid?

Hydrofluoric acid's weak acidity stems from its bond strength and dissociation behavior.

Factors Contributing to HF's Weakness

- Bond Strength: The H–F bond is one of the strongest among hydrogen halides, resisting dissociation.
- Hydrogen Bonding: HF molecules tend to form hydrogen bonds, stabilizing the undissociated form.
- Electronegativity: Fluorine's high electronegativity influences the bond's polarity but does not necessarily favor complete dissociation.

Dissociation Constant

The acid dissociation constant (K_a) quantifies acidity:

Acid	K _a Value	Acid Strength
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HF	~ 6.6 × 10 ⁻⁴	Weak
HCl	~ 1.3 × 10 ⁶	Strong
HBr	~ 1.0 × 10 ⁹	Strong
HNO ₃	~ 2.5 × 10 ⁵	Strong
HClO ₄	> 10 ⁷	Very strong

As shown, HF's K_a is significantly lower than the others, confirming its status as a weak acid.

Practical Implications of Acid Strength

Understanding acid strength is crucial in various contexts:

- Industrial Processes: Strong acids are used where complete proton donation is required.

- Biological Systems: Weak acids like HF are less aggressive but can be hazardous.
- Safety Precautions: Handling HF requires special safety measures due to its toxicity and ability to penetrate tissues.

Summary Table: Acid Strengths of the Given Options

Acid	Dissociation	Acid Strength	pH Range (Approximate)	Notes
HF	Partial	Weak	3–6	Corrosive, toxic, used in industry
HCl	Complete	Strong	< 3	Common laboratory acid
HBr	Complete	Strong	< 3	Used in organic synthesis
HNO ₃	Complete	Strong	< 1	Used in manufacturing and labs
HClO ₄	Complete	Strong	< 1	Used in rocket propellants

Additional Insights

Safety Considerations

- HF Safety: Due to its ability to penetrate tissues and cause deep burns, HF must be handled with extreme care, using appropriate PPE and protocols.
- Strong Acid Handling: Proper ventilation, protective gear, and training are essential when working with strong acids like HCl, HBr, HNO₃, and HClO₄.

Environmental Impact

- Disposal: Strong acids and HF should be neutralized properly before disposal to prevent environmental damage.
- Corrosion: These acids can corrode metals and infrastructure, so storage and handling require materials resistant to corrosion.

Final Verdict

Based on the chemical properties, dissociation behavior, and acid dissociation constants, HF (hydrofluoric acid) is the weak acid among the options listed.

Conclusion

Understanding the distinctions between strong and weak acids is foundational in chemistry. Hydrofluoric acid (HF) exemplifies a weak acid due to its partial dissociation in water, contrasting with its counterparts like HCl,

HBr, HNO_3 , and HClO_4 , which are strong acids with complete dissociation. Recognizing these properties enables chemists and students to predict acid behavior, safety precautions, and practical applications.

Remember: Always handle acids with care, especially weak acids like HF, which, despite their classification, pose significant health risks.

References

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- Housecroft, C. E., & Sharpe, A. G. (2012). Inorganic Chemistry. Pearson Education.
- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics. CRC Press.
- Safety Data Sheets (SDS) for HF and other acids.

This comprehensive guide aims to clarify the nature of acids, emphasizing why HF is classified as a weak acid among the options provided, equipping readers with knowledge to understand acid behavior in various contexts.

Frequently Asked Questions

Which of the following acids is considered a weak acid: HF, HCl, HBr, HNO_3 , or HClO_4 ?

HF (Hydrofluoric acid) is considered a weak acid among the options.

Why is HF classified as a weak acid compared to other halogen acids like HCl, HBr, and HClO_4 ?

HF is classified as a weak acid because it does not fully dissociate in water, unlike strong acids such as HCl, HBr, and HClO_4 , which dissociate completely.

What factors influence the strength of HF as a weak acid?

The strength of HF as a weak acid is influenced by its hydrogen-fluorine bond strength and its limited ability to ionize in water, resulting in partial dissociation.

Among the options, which acids are classified as strong acids?

HCl, HBr, and HClO₄ are classified as strong acids because they dissociate completely in aqueous solution.

Is HNO₃ considered a strong or weak acid, and why?

HNO₃ (Nitric acid) is considered a strong acid because it dissociates completely in water.

How does the dissociation of HF differ from that of HCl in aqueous solutions?

HF dissociates only partially in water, making it a weak acid, whereas HCl dissociates completely, classifying it as a strong acid.

What practical implications does the weak acidity of HF have in industrial and laboratory settings?

Due to its weak acidity and the toxicity of hydrofluoric acid, handling HF requires special precautions, and its limited dissociation affects its reactivity compared to strong acids.

Can HF be used to etch glass, and if so, why?

Yes, HF can etch glass because it reacts with silica (SiO₂), but its weak acid nature means it penetrates slowly and requires careful handling.

Additional Resources

Weak Acid: An In-Depth Analysis of HF Among Common Acids

Understanding Acids: Strong vs. Weak

Before delving into the specifics of each acid listed—HF, HCl, HBr, HNO₃, and HClO₄—it is essential to comprehend what distinguishes a weak acid from a strong acid. This fundamental knowledge provides the foundation for identifying HF as a weak acid.

Definition of Acids

- Acids are substances that donate protons (H^+ ions) in aqueous solutions.
- The strength of an acid depends on its degree of ionization in water.

Strong vs. Weak Acids

Aspect	Strong Acids	Weak Acids
Ionization in Water	Complete (or near-complete)	Partial
Degree of Ionization	Nearly 100%	Significantly less
Conductivity	High	Lower
Examples	HCl, HBr, HNO_3 , $HClO_4$	HF, Acetic acid, Phosphoric acid

Key Point: The strength of an acid is determined by its ability to ionize in water. Fully ionized acids are classified as strong; partially ionized acids are weak.

Examining the Listed Acids

Let's analyze each acid individually to understand their chemical nature, their typical behaviors in aqueous solutions, and why HF stands out as the weak acid among them.

1. Hydrofluoric Acid (HF)

Chemical Properties:

- Formula: HF
- Nature: Weak acid
- Behavior: Partially ionizes in water
- pKa: Approximately 3.2 (indicating weak acidity)
- Unique features: Exhibits strong hydrogen bonding, which affects its ionization and reactivity

Why Is HF a Weak Acid?

- Bond Strength: The H-F bond is one of the strongest among hydrogen halides due to fluorine's high electronegativity and small atomic radius. This bond strength hinders complete dissociation.
- Hydrogen Bonding: HF molecules tend to form extensive hydrogen bonds, which further stabilizes the molecule and reduces ionization.
- Degree of Ionization: In aqueous solution, only a small fraction (roughly 1-2%) of HF molecules release H^+ ions, confirming its weak acid status.

Implications of HF Being Weak:

- It does not readily release protons.
- It requires careful handling because it can penetrate tissues and cause severe chemical burns.
- Its limited ionization influences how it reacts in various chemical processes, especially in industrial applications like etching glass and in organic synthesis.

2. Hydrochloric Acid (HCl)

Chemical Properties:

- Formula: HCl
- Nature: Strong acid
- Behavior: Almost completely ionizes in water
- pKa: Around -6.3
- Uses: Cleaning, pH regulation, chemical synthesis

Ionization Behavior:

- Dissociates fully into H^+ and Cl^- ions
- Conducts electricity efficiently in aqueous solutions

3. Hydrobromic Acid (HBr)

Chemical Properties:

- Formula: HBr
- Nature: Strong acid
- Behavior: Nearly complete ionization
- pKa: About -9
- Industrial relevance: Used in organic synthesis and as a reagent

Ionization Behavior:

- Similar to HCl, HBr readily dissociates in water

4. Nitric Acid (HNO₃)

Chemical Properties:

- Formula: HNO₃
- Nature: Strong acid
- Behavior: Fully ionizes in aqueous solutions
- pKa: About -1.4
- Uses: Fertilizers, explosives, manufacturing

Ionization Behavior:

- Completely dissociates, producing H^+ and NO_3^- ions

5. Perchloric Acid (HClO₄)

Chemical Properties:

- Formula: HClO₄
- Nature: Strongest among common acids
- Behavior: Fully ionizes
- pKa: Around -10
- Applications: Analytical chemistry, rocket propellant

Ionization Behavior:

- Dissociates entirely in water, making it an extremely strong acid

Why Is HF Classified as a Weak Acid?

The classification hinges on its degree of ionization and bond strength, which are pivotal in understanding HF's behavior.

Bond Dissociation Energy (BDE):

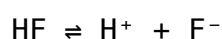
- The H–F bond has a BDE of approximately 565 kJ/mol, making it significantly stronger than other hydrogen halides like HCl (~430 kJ/mol) or HBr (~370 kJ/mol).
- The strong H–F bond resists cleavage in aqueous solutions, leading to partial ionization.

Hydrogen Bonding in HF

- HF molecules form extensive hydrogen-bond networks, which stabilize the molecular form.
- This extensive hydrogen bonding reduces the availability of free H⁺ ions in solution.

Solvation and Ionization Equilibrium

- In water, HF exists in an equilibrium:



- However, this equilibrium favors the undissociated form more than in strong acids, resulting in a lower concentration of free protons and fluoride ions.

Comparative pKa Values

- HF: pKa $\approx$ 3.2
- HCl: pKa $\approx$ -6.3
- HBr: pKa $\approx$ -9
- HNO₃: pKa $\approx$ -1.4
- HClO₄: pKa $\approx$ -10

The higher pKa of HF indicates a weaker acid relative to the others.

Industrial and Biological Significance of HF

Understanding HF's weak acidity is crucial not just academically but also practically.

Industrial Uses

- Glass etching and engraving: HF reacts with silica (SiO₂) to produce silicon tetrafluoride and other compounds.
- Organic synthesis: Used to introduce fluorine into organic molecules.
- Metal cleaning: Removes oxides and scales.

Biological and Toxicological Aspects

- Despite being a weak acid, HF is highly toxic.
- It can penetrate tissues, causing deep burns and systemic toxicity.
- Its fluoride ions can interfere with calcium metabolism, leading to hypocalcemia.

Safety and Handling Considerations

- Due to its ability to penetrate tissues, HF requires specialized handling and protective equipment.
- Emergency treatments include calcium gluconate gel to bind fluoride ions and mitigate tissue damage.

Summary and Key Takeaways

- Among the acids listed, HF is the only weak acid.
- The strength of an acid correlates with its degree of ionization, which for

HF is partial.

- The H-F bond's high bond dissociation energy and extensive hydrogen bonding network significantly reduce HF's ionization in water.
- Although weak in terms of acidity, HF's reactivity and toxicity demand respect and caution in practical applications.

Final Remarks

Understanding why HF is a weak acid involves appreciating its molecular structure, bonding characteristics, and behavior in aqueous solutions. Its unique properties distinguish it sharply from other common hydrogen halides, which are strong acids due to their weaker bonds and less extensive hydrogen bonding. Recognizing these chemical nuances not only enriches fundamental chemistry knowledge but also informs safe handling practices and practical applications of these acids.

In conclusion, when considering the list provided—HF, HCl, HBr, HNO₃, and HClO₄—it is clear that HF stands out as a weak acid based on its incomplete ionization, high bond strength, and hydrogen bonding tendencies, making it a fascinating subject of study in both academic and industrial contexts.

[15 Of The Following Is A Weak Acid A Hf B Hcl C Hbr D Hno3e Hcio4](#)

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