

$$\frac{x^2}{(5.6 \times 10^{-3} - x)} = 7.94 \times 10^{-5}$$

Predict whether a simplifying assumption is justified ...

$$\frac{[\text{HA}]_{\text{initial}}}{K_a} = \frac{5.6 \times 10^{-3}}{7.94 \times 10^{-5}}$$

$$\frac{[\text{HA}]_{\text{initial}}}{K_a} = 70$$

Since $70 < 100$, we may not assume that $5.6 \times 10^{-3} - x \doteq 5.6 \times 10^{-3}$.

$$\frac{x^2}{(5.6 \times 10^{-3} - x)} = 7.94 \times 10^{-5}$$

$$x^2 = 7.94 \times 10^{-5} (5.6 \times 10^{-3} - x)$$

$$x^2 + (7.94 \times 10^{-5} x) - (4.45 \times 10^{-7}) = 0$$

$$x = \frac{-7.94 \times 10^{-5} \pm \sqrt{(7.94 \times 10^{-5})^2 - 4(-4.45 \times 10^{-7})}}{2}$$

$$x = 6.29 \times 10^{-4} \text{ mol/L}$$

$$\text{pH} = -\log[\text{H}_{(\text{aq})}^+]$$

$$= -\log[6.29 \times 10^{-4}]$$

$$\text{pH} = 3.20$$

The pH of the lactic acid in the runner's muscles is 3.20.

(b) Lactic acid buildup in muscles causes fatigue, pain, and muscle stiffness.

(c) Muscles can oxidize glucose aerobically or anaerobically to release energy. The energy released is stored temporarily in the molecule ATP that can then be used by muscles to do mechanical work. Anaerobic oxidation of glucose, however, is not very efficient. In a sprint, for example, a great deal of energy is required in a short period of time. Anaerobic oxidation supplies most of this energy but is very inefficient. Short-term energy reserves are depleted quickly and lactic acid accumulates.

Muscles used in long-distance running rely more on aerobic oxidation of glucose for their energy. When running at a comfortable pace, both systems of oxidation are used but the ratio of anaerobic: aerobic is low enough to prevent lactic acid from accumulating. As the pace increases, the anaerobic: aerobic ratio increases to the point where lactic acid begins to accumulate in the blood. This is known as the lactic acid threshold. In order to improve performance, long-distance runners try to train at the speed at which the lactic acid threshold occurs. This serves to increase the threshold and overall performance.

8.3 ACID-BASE PROPERTIES OF SALT SOLUTIONS

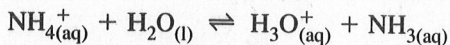
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Understanding Concepts

- The ammonium ion is a weak acid with $K_a = 5.8 \times 10^{-10}$. The phosphate ion is a base with $K_b = 2.4 \times 10^{-2}$. Since K_b is larger than K_a , an ammonium phosphate solution is basic.
 - The ammonium ion is a weak acid with $K_a = 5.8 \times 10^{-10}$. The sulfate ion is a base with $K_b = 1.0 \times 10^{-12}$. Since K_a is larger than K_b , an ammonium sulfate solution is slightly acidic.
 - Magnesium oxide reacts with water to form magnesium hydroxide (a base).
 - $\text{MgO}_{(\text{s})} + \text{H}_2\text{O}_{(\text{l})} \rightarrow \text{Mg}_{(\text{aq})}^{2+} + 2 \text{OH}_{(\text{aq})}^-$. This makes a solution of magnesium oxide basic.
- A solution of sodium sulfite will be basic.
- $\text{NH}_4\text{NO}_3_{(\text{aq})} \rightarrow \text{NH}_4_{(\text{aq})}^+ + \text{NO}_3_{(\text{aq})}^-$

Since NO_3^- is the conjugate base of a strong acid, it will not affect the pH of the solution. NH_4^+ is the conjugate acid of a weak base NH_3 , so it will hydrolyze according to the equation:



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NH}_3(\text{aq})]}{[\text{NH}_4^+]}$$

$$K_a = 5.8 \times 10^{-10}$$

ICE Table for the Hydrolysis of NH_4^+						
	NH_4^+	$\text{H}_2\text{O}(\text{l})$	\rightleftharpoons	H_3O^+	$+$	$\text{NH}_3(\text{aq})$
Initial concentration (mol/L)	0.30	–		0.00		0.00
Change in concentration (mol/L)	–x	–		+x		+x
Equilibrium concentration (mol/L)	0.30 – x	–		x		x

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NH}_3(\text{aq})]}{[\text{NH}_4^+]}$$

$$K_a = 5.8 \times 10^{-10}$$

$$\frac{x^2}{0.30 - x} = 5.8 \times 10^{-10}$$

Predicting whether $0.30 - x \approx 0.30$...

$$\frac{[\text{HA}]_{\text{initial}}}{K_a} = \frac{0.30}{5.8 \times 10^{-10}}$$

$$\frac{[\text{HA}]_{\text{initial}}}{K_a} = 5.2 \times 10^8$$

Since $5.2 \times 10^8 > 100$, we may assume that $0.30 - x \approx 0.30$.

$$\frac{x^2}{0.30} \approx 5.8 \times 10^{-10}$$

$$x^2 \approx 1.7 \times 10^{-10}$$

$$x \approx 1.3 \times 10^{-5}$$

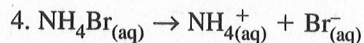
$$\text{Since } x = [\text{H}_3\text{O}^+]$$

$$[\text{H}_3\text{O}^+] = 1.3 \times 10^{-5} \text{ mol/L}$$

$$\text{pH} = -\log 1.3 \times 10^{-5}$$

$$\text{pH} = 4.88$$

The pH of a 0.30 mol/L ammonium nitrate solution is 4.88.



Since Br^- is the conjugate base of a strong acid, it will not affect the pH of the solution. NH_4^+ hydrolyzes according to the equation:



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NH}_3(\text{aq})]}{[\text{NH}_4^+]}$$

$$K_a = 5.8 \times 10^{-10}$$

ICE Table		the Hydrolysis of $\text{NH}_4^+(\text{aq})$
Initial concentration (mol/L)	0.25	$\text{H}_3\text{O}^+(\text{aq})$ 0.00
Change in concentration (mol/L)	$-x$	$+x$
Equilibrium concentration (mol/L)	$0.25 - x$	x

$$K_a = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{NH}_3(\text{aq})]}{[\text{NH}_4^+(\text{aq})]}$$

$$K_a = 5.8 \times 10^{-10}$$

$$\frac{x^2}{0.25} = 5.8 \times 10^{-10}$$

Predicting whether $x \approx 0.25$

$$\frac{[\text{H}^+]_{\text{initial}}}{K_a} = \frac{0.25}{5.8 \times 10^{-10}}$$

$$\frac{[\text{A}^-]_{\text{initial}}}{K_a} = \frac{0.25}{5.8 \times 10^{-10}}$$

Since $0.25 \times 10^9 \gg 5.8 \times 10^{-10}$, we may assume $0.25 - x \approx 0.25$

$$\frac{x^2}{0.25} = 5.8 \times 10^{-10}$$

$$x^2 = 1.45 \times 10^{-10}$$

$$x = 1.2 \times 10^{-5}$$

Since

$$[\text{H}_3\text{O}^+] = 1.2 \times 10^{-5} \text{ mol/L}$$

The pH of an ammonium bromide solution is 4.92.

5. $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2(\text{aq}) + \text{C}_2\text{H}_3\text{O}_2^{2-}(\text{aq})$. The ammonium ion is a weak acid with $K_a = 5.8 \times 10^{-10}$. Since K_b and K_a are similar, an ammonium acetate solution is a weak base 6×10^{-10} .

Making Connections

6. Fertilizers contain ammonium compounds, which hydrolyze to produce acidic solutions, and

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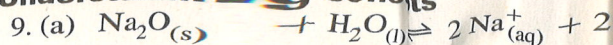
Understanding Concepts

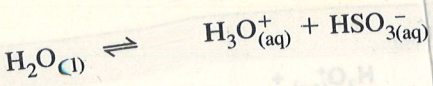
7. $\text{HCO}_3^-(\text{aq})$, $\text{HS}^-(\text{aq})$, $\text{H}_2\text{PO}_4^-(\text{aq})$, $\text{HS}^-(\text{aq})$, $\text{HSO}_3^-(\text{aq})$, $\text{HC}_2\text{O}_4^-(\text{aq})$
8. (a) acidic
(b) basic

PRACTICE

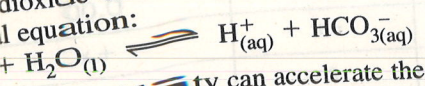
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Understanding Concepts

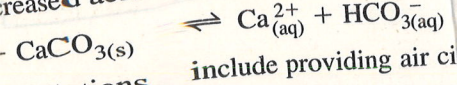




Carbon dioxide exhaled by the visitors cause the acidity of the moisture in the caves, according to the



Increased acidity can accelerate the dig of the cave structures:



Some solutions include providing air cirm systems or large fans that would prevent carbon dioxide gas

accumulating, the use of fluoride:

Studies supporting the use of fluoride: studies of large populations suggest ther fluoridation does prevent tooth decay.

Arguments against the use of fluoride: other studies suggest that the evidencpport that water fluoridation prevents tooth decay is inconclu-

risks associated with long-term exposure amounts of fluoride have not been established.

The effects of fluoride on aquatic life have non thoroughly studied.

Some studies suggest that prolonged exposure fluoride is associated with a condition known as skeletal fluorosis

gradual deterioration of bone. fluoride can be administered in more direct what do not threaten the environment.

CE

4)

Understanding Concepts

- Lewis acid: $\text{H}^+_{(aq)}$; Lewis base: $\text{OH}^-_{(aq)}$
- Lewis acid: $\text{H}^+_{(aq)}$; Lewis base: $\text{NH}_3_{(aq)}$

SECTION 8.3 QUESTIONS

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Understanding Concepts

- a) Neutral. The sodium ion, being a member of Group 1, does not hydrolyze. The chloride ion is an extremely weak base and therefore also does not hydrolyze.
- b) Acidic. Chloride does not hydrolyze. Aluminum ions will hydrolyze according to the equation

$$\text{Al}(\text{H}_2\text{O})_6^{3+} \rightleftharpoons \text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+}_{(aq)} + \text{H}^+_{(aq)}$$
- c) Basic. The sodium ion does not hydrolyze. Carbonate will hydrolyze to release hydroxide ions.

$$\text{CO}_3^{2-}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{OH}^-_{(aq)} + \text{HCO}_3^-_{(aq)}$$

The ammonium ion is a weak acid with $K_a = 5.8 \times 10^{-10}$. The carbonate ion is a base with $K_b = 2.1 \times 10^{-4}$. Since K_b is larger than K_a , an ammonium carbonate solution is basic.

According to Table C7 in the Appendix, the strongest possible acid is perchloric acid and the strongest possible base is the hydroxide ion, $\text{OH}^-_{(aq)}$ – the base released when the hydroxide ion dissociates. However, for all practical purposes, the concentration of oxide in a solution of the hydroxide ion is zero.

4. $\text{BeCl}_2_{(aq)}$ will turn litmus red because the $\text{Be}^{2+}_{(aq)}$ hydrolyzes to release $\text{H}^+_{(aq)}$.

- 5. (a) acidic
- (b) basic

Applying Inquiry Skills

6. Analysis
- | | |
|-----------------------------|-------|
| $\text{Na}_2\text{O}_{(s)}$ | basic |
| $\text{MgO}_{(s)}$ | basic |