ANSWER KEY.

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8.1 Introduction to Acids and Bases

AP Chemistry | ANSWER KEY

Show your work. Use $K_w = 1.0 \times 10^{-14}$ at 25 °C unless told otherwise.

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1. Ammonia reacts with water: $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

(a) In the forward reaction, which species is the Brønsted-Lowry acid and which is the base?

(b) Label the two conjugate acid-base pairs.

(a) **Acid: H_2O (donates H^+). Base: NH_3 (accepts H^+).**

(b) **Pair 1: NH_3 (base) and NH_4^+ (conjugate acid). Pair 2: H_2O (acid) and OH^- (conjugate base).**

2. Water ionizes slightly. At 25 °C, $K_w = 1.0 \times 10^{-14}$. At 50 °C, $K_w = 5.5 \times 10^{-14}$.

(a) Write the equation for the autoionization of water and the K_w expression.

(b) Is the autoionization of water endothermic or exothermic? Use the K_w values to explain.

(a) **$2\ H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$**

$K_w = [H_3O^+][OH^-]$

(b) **Endothermic.** K_w increases when the temperature increases, so heating shifts the equilibrium toward products. Heat acts like a reactant.

3. At 25 °C, a solution has $[H_3O^+] = 3.2 \times 10^{-4}\ M$. Find the pH, the pOH, and $[OH^-]$. Is the solution acidic, basic, or neutral?

$pH = -\log(3.2 \times 10^{-4}) =$ **3.49**

$pOH = 14.00 - 3.49 =$ **10.51**

$[OH^-] = K_w / [H_3O^+] = (1.0 \times 10^{-14}) / (3.2 \times 10^{-4}\ M) =$ **$3.1 \times 10^{-11}\ M$**

Acidic (pH below 7, $[H_3O^+]$ greater than $[OH^-]$).

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4. At 25 °C, a solution has a pH of 9.15. Find $[H_3O^+]$ and $[OH^-]$.

$[H_3O^+] = 10^{-pH} = 10^{-9.15} =$ **7.1×10^{-10} *M***

pOH = 14.00 − 9.15 = 4.85, so $[OH^-] = 10^{-4.85} =$ **1.4×10^{-5} *M***

5. Pure water at 50 °C has $K_w = 5.5 \times 10^{-14}$.

(a) Calculate $[H_3O^+]$ and the pH of pure water at 50 °C.

(b) Is the water acidic, basic, or neutral? Explain.

(a) In pure water $[H_3O^+] = [OH^-]$, so $[H_3O^+] = \sqrt{(5.5 \times 10^{-14})} =$ **2.35×10^{-7} *M***

pH = $-\log(2.35 \times 10^{-7}) =$ **6.63**

(b) **Neutral.** $[H_3O^+]$ still equals $[OH^-]$. Neutral is not always pH 7; it moves lower as K_w grows with temperature.

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