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Acid-Base Equilibria

The problem requires calculating the hydrogen ion concentration **$[H^+]$**, pH, and pOH of given solutions at 25°C based on given hydroxide ion concentrations **$[OH^-]$**. Additionally, identifying whether the solution is acidic, neutral, or basic is required.

(a) Given $[OH^-] = 2.4$ M

Step 1: Calculating $[H^+]$

At 25°C, the relationship between $[H^+]$ and $[OH^-]$ is given by the water dissociation constant, $\mathbf{K_w}$:

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$

Given:

$[OH^-] = 2.4\ M$

$[H^+] = {}^{1.0 \times 10^{-14}}/_{2.4} = 4.17 \times 10^{-15}\ M$

Explanation: Using the relationship of K_w to find $[H^+]$ from a known $[OH^-]$.

Supporting statement: The hydrogen ion concentration $[H^+]$ is calculated using the water dissociation constant.

Step 2: Calculating pH and pOH

The pOH is calculated using:

$pOH = -log([OH^-])$

$pOH = -log(2.4) = -0.38\ (approx)$

The pH is calculated using:

$pH = 14 - pOH$

$pH = 14 + 0.38 = 14.38$

Explanation: The pOH is obtained using the logarithmic relationship, and pH is found knowing the sum of pH and pOH is 14.

Supporting statement: The pH and pOH values provide insight into the acidity and basicity of the solution.

Step 3: Identifying the Solution

Since pH is greater than 7, the solution is:

Basic

Explanation: A pH greater than 7 indicates a basic solution.

(b) Given $[OH^-] = 5.4 \times 10^{-15}$ M

Step 1: Calculating $[H^+]$

Given:

$[OH^-] = 5.4 \times 10^{-15}\ M$

$[H^+] = {}^{1.0 \times 10^{-14}}/_{5.4 \times 10^{-15}} = 1.85\ M$

Explanation: Again, the relationship of K_w is used to discover $[H^+]$.

Supporting statement: The hydrogen ion concentration $[H^+]$ is essential for determining the acidity of the solution.

Step 2: Calculating pH and pOH

The pOH is calculated as follows:

pOH = -log([OH^-])

pOH = -log(5.4 × 10^{-15}) = 14.27 (approx)

The pH is determined by:

pH = 14 - pOH

pH = 14 - 14.27 = -0.27

Explanation: The pOH is derived from the logarithmic value of [OH^-], and pH is computed.

Supporting statement: The pH and pOH values indicate the nature of the solution.

Step 3: Identifying the Solution

Since pH is less than 7, the solution is:

Acidic

Explanation: A pH value of less than 7 signifies an acidic solution.

Final Solution:

- **Part (a):**
  - [H^+] = 4.17 × 10^{-15} M
  - pH = 14.38
  - pOH = -0.38
  - The solution is Basic.
- **Part (b):**
  - [H^+] = 1.85 M
  - pH = -0.27
  - pOH = 14.27
  - The solution is Acidic.

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