CheggSolutions - Thegdp

Chemistry

Acid-Base Equilibria

The problem involves the acid dissociation constant (\(\text{p}K_a\)) of pyruvic acid and its behavior in an acidic/basic environment. The objective is to determine which form of pyruvic acid predominates at a given pH.

- \(\text{p}K_a \) of pyruvic acid = 2.50

- Conjugate base of pyruvic acid = pyruvate

- Given pH = 7.4

Step 1: Understanding the Relationship Between \(\text{p}K_a \) and pH

The Henderson-Hasselbalch equation relates the pH, \(\text{p}K_a \), and the ratio of the concentrations of the deprotonated (A^-) to protonated (HA) forms of an acid:

\[\text{pH} = \text{p}K_a + \log \left(\frac{[\text{A}^-]}{[\text{HA}]} \right) \]

Explanation: In this equation:

- \([\text{A}^-] \) represents the concentration of the conjugate base (pyruvate).

- \([\text{HA}] \) represents the concentration of the acid (pyruvic acid).

Step 2: Plugging in Values into the Henderson-Hasselbalch Equation

Given:

- \(\text{p}K_a = 2.50 \)

- \(\text{pH} = 7.4 \)

Using the equation:

\[7.4 = 2.50 + \log \left(\frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \right) \]

Explanation: The equation sets pH to 7.4 and \(\text{p}K_a \) to 2.50. The goal is to solve for the ratio of pyruvate to pyruvic acid.

Step 3: Solving for the Ratio \(\frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \)

Rearrange the equation to isolate the logarithmic term:

\[7.4 - 2.50 = \log \left(\frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \right) \]

Calculate the difference:

\[4.9 = \log \left(\frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \right) \]

Explanation: Isolate the logarithmic term by subtracting \(\text{p}K_a \) from the pH.

Step 4: Exponentiating Both Sides to Solve for the Ratio

\[10^{4.9} = \frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \]

Calculate \(10^{4.9} \):

$$ 10^{4.9} \approx 79432.82 $$

Explanation: Exponentiating both sides allows solving the concentration ratio directly.

Step 5: Interpreting the Result

The ratio $\frac{[\text{pyruvate}]}{[\text{pyruvic acid}]} \approx 79432.82$ indicates that the concentration of pyruvate is vastly greater than that of pyruvic acid at pH 7.4.

Explanation: Since $10^{4.9}$ is a very large number, it shows that pyruvate predominates at pH 7.4 compared to pyruvic acid.

Final Solution:

The form of pyruvic acid that predominates at pH 7.4 is pyruvate.