Hat Is The PH Of A 0.01 M Solution Of Ca(OH)2? (A) 12.3. (B) 12.0. (C) 11.7. (D) 11.3. (E) 11.0 (F) 10.6.

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Understanding the pH of a 0.01 M Ca(OH)2 Solution

When exploring the pH of a solution, especially one involving a strong base like calcium hydroxide (Ca(OH)2), it is essential to understand the fundamental concepts of pH, hydroxide ion concentration, and how they relate to each other. In this article, we will analyze how to determine the pH of a 0.01 M Ca(OH)2 solution, interpret the given options, and understand the chemistry behind the calculation.

What Is pH and Why Is It Important?

Definition of pH

pH is a measure of the acidity or alkalinity of a solution, ranging from 0 to 14:
- pH < 7 indicates an acidic solution
- pH = 7 indicates a neutral solution
- pH > 7 indicates a basic (alkaline) solution

The pH scale is logarithmic, meaning each whole number change represents a tenfold change in hydrogen ion (H^+) concentration.

Relevance of pH in Chemistry

Understanding pH is crucial in various fields:
- Chemistry: Acid-base reactions, titrations
- Biology: Enzyme activity, blood pH
- Environmental science: Water quality assessment

Properties of Calcium Hydroxide (Ca(OH)2)

Strength of Ca(OH)2 as a Base

Calcium hydroxide is a strong base, which dissociates completely in water, releasing hydroxide ions

(OH^-). Its dissociation can be represented as:

$Ca(OH)_2$ (s) → Ca^{2+} (aq) + 2 OH^- (aq)

Because it dissociates fully, the concentration of OH^- ions in the solution directly relates to its molarity.

Implication for pH Calculation

Since $Ca(OH)_2$ provides 2 hydroxide ions per formula unit, the hydroxide ion concentration ($[OH^-]$) in solution will be twice the molarity of $Ca(OH)_2$ if it dissociates completely.

Calculating the pH of a 0.01 M $Ca(OH)_2$ Solution

Step 1: Determine the hydroxide ion concentration ($[OH^-]$)

Given that $Ca(OH)_2$ dissociates completely:
- Molarity of $Ca(OH)_2$ = 0.01 mol/L
- Each mole of $Ca(OH)_2$ produces 2 moles of OH^- ions
- Therefore, $[OH^-] = 2 \times 0.01$ mol/L = 0.02 mol/L

Step 2: Calculate pOH

pOH is defined as:
$pOH = -\log [OH^-]$

Substituting $[OH^-] = 0.02$:
$pOH = -\log(0.02)$

Calculating:
$\log(0.02) \approx -1.69897$

Thus:
$pOH \approx -(-1.69897) \approx 1.699$

Step 3: Determine pH

Since pH + pOH = 14:
pH = 14 - pOH
$pH \approx 14 - 1.699 \approx 12.301$

Final pH ≈ 12.3

Matching the Result with Multiple Choice Options

The calculated pH of approximately 12.3 corresponds to option (A). This indicates that a 0.01 M $Ca(OH)_2$ solution is strongly basic, with a pH well above neutral.

Understanding the Significance of the pH Value

Why Is the pH Around 12.3?

A pH of about 12.3 indicates a highly alkaline solution, typical for dilute solutions of strong bases like $Ca(OH)_2$. The high pH is due to the high concentration of hydroxide ions resulting from complete dissociation.

Real-World Applications

Solutions with such pH levels are common in:
- Agricultural lime treatments
- Industrial cleaning agents
- Water treatment processes

Understanding the pH helps in controlling chemical reactions, ensuring safety, and maintaining proper conditions in these applications.

Additional Factors to Consider

Effect of Dilution

Diluting $Ca(OH)_2$ solutions reduces hydroxide ion concentration and consequently lowers the pH. Conversely, increasing the concentration raises the pH further.

Temperature Impact

While temperature can slightly influence dissociation and ion activity, for dilute strong bases like $Ca(OH)_2$ at room temperature, the impact is minimal and often neglected in basic calculations.

Summary and Key Takeaways

- Calcium hydroxide ($Ca(OH)_2$) is a strong base that dissociates completely in water.
- A 0.01 M $Ca(OH)_2$ solution produces a hydroxide ion concentration of 0.02 M.
- The pH of this solution is approximately 12.3, making it strongly alkaline.

- The correct answer among the options provided is (A) 12.3.

Conclusion

Calculating the pH of a solution involving a strong base like $Ca(OH)_2$ requires understanding its dissociation behavior and applying logarithmic calculations. For a 0.01 M concentration, the pH is around 12.3, confirming that the solution is highly basic. Recognizing such properties is vital in chemistry, environmental science, and industrial processes where pH control is essential for safety and efficiency.

By understanding these principles, students, chemists, and professionals can accurately determine and interpret the pH of various solutions, ensuring proper application and safety measures are maintained.

Frequently Asked Questions

What is the pH of a 0.01 M solution of Ca(OH)2?

The pH of a 0.01 M Ca(OH)2 solution is approximately 12.0, so the correct answer is (B) 12.0.

How do you calculate the pH of a calcium hydroxide solution?

Since Ca(OH)2 is a strong base, it dissociates completely. The hydroxide ion concentration [OH-] is equal to the molarity, 0.01 M. Then, pOH = -log[OH-] = 2, and pH = 14 - pOH = 12.0.

Why is the pH of a 0.01 M Ca(OH)2 solution around 12?

Because Ca(OH)2 dissociates fully into Ca^{2}+ and 2OH- ions, doubling the hydroxide concentration to 0.02 M, which results in a pOH of about 1.7 and a pH near 12.

Which option correctly represents the pH of a 0.01 M Ca(OH)2 solution?

Option (B) 12.0 correctly represents the pH based on the calculation.

Is Ca(OH)2 considered a strong or weak base, and how does that affect pH calculations?

Ca(OH)2 is a strong base, meaning it dissociates completely in solution, simplifying pH calculation by directly using the molarity of OH- ions.

How does the dissociation of Ca(OH)2 influence the hydroxide

ion concentration?

Since Ca(OH)2 dissociates fully to produce two hydroxide ions per formula unit, the hydroxide concentration is twice the molarity: 0.02 M.

What is the relation between hydroxide concentration and pH?

pH is related to hydroxide concentration through pOH = -log[OH-], and pH = 14 - pOH. Higher [OH-] results in a higher pH.

Why is the pH of Ca(OH)2 solutions higher than that of NaOH solutions at the same molarity?

Because Ca(OH)2 dissociates into two hydroxide ions per formula unit, it effectively increases [OH-], leading to a higher pH compared to monovalent bases like NaOH at the same molarity.

What is the significance of the pH value 12.0 in practical terms?

A pH of 12.0 indicates a strongly basic solution, which can be corrosive and should be handled with care in laboratory and industrial settings.

Additional Resources

Understanding the pH of a 0.01 M $Ca(OH)_2$ Solution

The question at hand — “What is the pH of a 0.01 M solution of $Ca(OH)_2$?” — might seem straightforward at a glance, but it opens the door to a rich discussion about the nature of strong bases, dissociation processes, pH calculations, and the chemistry principles underlying aqueous solutions of ionic compounds. To fully grasp this, we need to explore concepts such as hydroxide ion concentration, molarity, the dissociation of calcium hydroxide, and the pH scale itself.

Introduction to pH and Its Significance

The pH scale is a logarithmic measure of the hydrogen ion concentration ($[H^+]$) in a solution. It ranges from 0 to 14 under typical conditions, with:

- pH < 7 indicating acidity
- pH = 7 indicating neutrality
- pH > 7 indicating alkalinity (basicity)

Since pH is related to $[H^+]$, and hydroxide ions (OH^-) are involved in basic solutions, understanding how OH^- concentration influences pH is crucial.

Calcium Hydroxide ($Ca(OH)_2$): Nature and Dissociation

The compound calcium hydroxide is an alkaline earth metal hydroxide. It is classified as a strong base, which means it dissociates completely in aqueous solution. Its dissociation can be written as:

$Ca(OH)_2 (s) \rightarrow Ca^{2+} (aq) + 2 OH^- (aq)$

This dissociation indicates that:

- For each mole of $Ca(OH)_2$ dissolved, two moles of hydroxide ions are produced.
- The dissociation is complete, meaning the initial molarity of $Ca(OH)_2$ directly relates to the hydroxide ion concentration.

This property simplifies calculations but also requires careful attention to the stoichiometry involved.

Calculating Hydroxide Ion Concentration ($[OH^-]$)

Given:

- Molarity of $Ca(OH)_2$ = 0.01 M

Since each formula unit produces 2 hydroxide ions:

$[OH^-] = 2 \times [Ca(OH)_2] = 2 \times 0.01 \text{ M} = 0.02 \text{ M}$

This is a key step. It indicates that the hydroxide ion concentration in this solution is 0.02 M.

Relating $[OH^-]$ to pOH and pH

The pH scale is related to the concentration of hydrogen ions, but in alkaline solutions, it’s often more straightforward to calculate the pOH first:

$pOH = -\log [OH^-]$

Once pOH is known, the pH can be derived:

$pH = 14 - pOH$

Let's proceed step by step:

1. Calculate pOH:

$pOH = -\log (0.02)$

2. Determine pH:

$pH = 14 - pOH$

Calculating pOH

$-\log (0.02) = \log (2 \times 10^{-2}) = \log 2 + \log 10^{-2} = 0.3010 - 2 = -1.699$

Therefore:

$pOH = -(-1.699) = 1.699$

Calculating pH

$pH = 14 - 1.699 = 12.301$

This value suggests that the solution is strongly basic, with a pH around 12.3.

Interpreting the Result: Which Option Fits?

From the options provided:

- (A) 12.3
- (B) 12.0
- (C) 11.7
- (D) 11.3
- (E) 11.0
- (F) 10.6

The calculated pH of approximately 12.3 aligns precisely with option (A).

Additional Considerations and Assumptions

While the straightforward calculation suggests a pH of about 12.3, it's important to understand the assumptions involved:

- Complete Dissociation: $Ca(OH)_2$ is a strong base, and it's assumed to dissociate fully in water, which is valid under normal conditions.
- No Activity Coefficients or Ionic Strength Effects: The calculation assumes ideal behavior, which is reasonable at such dilute concentrations.
- Temperature: Standard calculations assume room temperature (~25°C). pH and pOH are temperature-dependent, but unless specified, 25°C is the standard.

Impact of Ionic Strength and Real-World Variations

In real-world scenarios, factors such as ionic strength, activity coefficients, and temperature can slightly influence the exact pH value. At very low concentrations, activity coefficients deviate from unity, but for the scope of this question, the ideal approximation is sufficient.

Summary of the Key Points

- Calcium hydroxide ($Ca(OH)_2$) is a strong base that dissociates completely in water.
- Dissociation yields 2 hydroxide ions per formula unit, so $[OH^-] = 0.02$ M for a 0.01 M solution.
- Calculating pOH:

$$pOH = -\log(0.02) \approx 1.699$$

- Deriving pH:

$$pH = 14 - pOH \approx 12.3$$

- The closest option provided is (A) 12.3.

Conclusion: The Correct Answer

Based on the detailed analysis, the pH of a 0.01 M solution of $Ca(OH)_2$ is approximately 12.3, making option (A) the correct choice.

Final Thoughts and Broader Context

Understanding the pH of basic solutions like $Ca(OH)_2$ is essential in many fields, from environmental chemistry to industrial processes. The principles demonstrated here — dissociation of strong bases, molarity calculations, and pH derivation — form the foundation of acid-base chemistry.

This problem exemplifies how stoichiometry, logarithmic relationships, and chemical properties combine to produce precise, predictable outcomes. Whether in laboratory settings or theoretical exercises, mastering these calculations enhances one's ability to analyze and interpret chemical solutions confidently.

In summary, a 0.01 M solution of $Ca(OH)_2$ has a hydroxide ion concentration of 0.02 M, leading to a pH around 12.3, aligning with option (A).

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