Marks
8

- Hydrochloric acid in a healthy human stomach leads to a pH in the range 1-2. What is the concentration of hydrochloric acid in the stomach?

As pH = -log$_{10}$[H_3O^+(aq)] and HCl is a strong acid, these pH values correspond to:

[H_3O^+(aq)] = 10^{-pH} = 0.1 M at pH = 1

[H_3O^+(aq)] = 10^{-pH} = 0.01 M at pH = 2

Answer: **0.01 – 0.1 M**

The stomach also contains considerable amounts of chloride ions, the conjugate base of hydrochloric acid, in the form of dissolved KCl and NaCl. Is this solution a buffer? Explain your answer.

No. A buffer contains a mixture of a *weak* acid and its conjugate base. HCl is a very, very strong acid and so Cl^- is a very, very weak base.

If acid is added to the stomach, there is no base for it to react with and so the pH will lower considerably.

If base is added to the stomach, it will react with the H_3O^+ present and the pH will rise considerably.

This is *not* the action of a buffer.

Milk of magnesia is often taken to reduce the discomfort of acid stomach. A teaspoon of milk of magnesia, containing 0.400 g of $Mg(OH)_2$, is added to a 0.300 L stomach solution with a pH of 1.3. What is the final pH of the solution?

The molar mass of $Mg(OH)_2$ is (24.31 (Mg) + 2 × 16.00 (O) + 2 × 1.008 (H)) g mol^{-1} = 58.326 g mol^{-1}.

The number of moles in 0.400 g is therefore:

number of moles = mass / molar mass
= (0.400 g) / (58.326 g mol^{-1}) = 0.00686 mol

The number of moles of OH^- added to the stomach is therefore:

number of moles of OH^- = 2 × 0.00686 mol = 0.0137 mol

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If the pH is originally 1.3, $[H_3O^+(aq)] = 10^{-pH} = 10^{-1.3} = 0.050$ M. The number of moles originally present in 0.300 L is therefore:

number of moles of H_3O^+ = concentration × volume
$= (0.050 \text{ mol L}^{-1}) \times (0.300 \text{ L}) = 0.0150$ mol

This will react with the added OH^-, leaving:

number of moles of H_3O^+ = (0.0150 – 0.0137) mol = 0.0013 mol

Hence, the final concentration of H_3O^+ is

$[H_3O^+(aq)]$ = number of moles / volume
= (0.0013 mol) / (0.300 L) = 0.0043 M

Finally,

$pH = -\log_{10}[H_3O^+(aq)] = 2.4$

Answer: **2.4**