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list of common buffer solutions

Published: September 3, 2026 | Index ID: #-

Understanding Buffer Solutions: A Comprehensive Guide

Buffers are essential in countless scientific, industrial, and everyday contexts. From maintaining the pH of blood to stabilizing the environment inside a laboratory experiment, a good buffer solution ensures that the acidity or basicity of a mixture remains within a desired range, even when small amounts of acids or bases are added. In this article, we will dive deep into the concept of buffer solutions, explore the chemistry behind them, and present a **list of common buffer solutions** that are frequently used in research, industry, and everyday life.

What is a Buffer Solution?

A buffer is a solution that resists changes in pH when small amounts of an acid or a base are introduced. This ability is critical in many biological and chemical processes where precise pH control is required. Buffers typically consist of a weak acid and its conjugate base, or a weak base and its conjugate acid, in roughly equal concentrations. The equilibrium between the acid and base components absorbs excess hydrogen ions (H z) or hydroxide ions (OH {), thereby minimizing pH fluctuations.

Key Components of a Buffer System

- Weak Acid – Provides hydrogen ions (H z) when needed.
- Conjugate Base – Accepts hydrogen ions, forming the weak acid.
- Concentration Ratio – The ratio between the acid and base determines the buffer's effective pH range.
- Buffer Capacity – A measure of how much acid or base a buffer can neutralize before the pH changes significantly.

Why Buffers Matter in Everyday Life

Think of your body's pH regulation. Blood maintains a pH of around 7.4, and any deviation can lead to serious health problems. Buffers in the bloodstream, such as bicarbonate and phosphate systems, keep this pH stable. In the kitchen, the acidity of vinegar and the alkalinity of baking soda create a buffer that can help in baking and cleaning. Even in environmental science, soil buffers protect ecosystems from sudden pH changes caused by acid rain or industrial runoff.

Preparing a Buffer Solution: The Basic Steps

Creating a buffer solution involves careful measurement and mixing of its components. Below is a general guide that applies to most buffer preparations:

1. Determine the Desired pH – Use the Henderson-Hasselbalch equation to calculate the ratio of acid to base needed for the target pH.
2. Choose the Buffer Pair – Select a weak acid/base pair that has a pKa close to the desired pH.
3. Calculate Concentrations – Decide on the total buffer concentration and split it between the acid and base forms according to the ratio.
4. Dissolve Components – Add the calculated amounts of acid and conjugate base to distilled water.
5. Adjust pH – Use a calibrated pH meter to fine-tune the solution, adding small amounts of acid or base if necessary.
6. Filter and Store – Filter the solution to remove any particulates and store it in a clean, labeled container.

A List of Common Buffer Solutions and Their Applications

Below we present an extensive list of buffer solutions that are widely used across various fields. Each entry includes the chemical composition, typical pH range, and common applications.

1. Phosphate Buffers

- Composition – Disodium phosphate (Na ,HPO „) and monosodium phosphate (NaH ,PO „).
- Typical pH Range – 5.8 to 8.0.
- Applications – Cell culture media, DNA extraction, protein purification, and biochemical assays.

2. Tris-HCl Buffer

- Composition – Tris (tris(hydroxymethyl)aminomethane) and hydrochloric acid.
- Typical pH Range – 7.0 to 9.0.
- Applications – Electrophoresis, enzyme kinetics, and protein crystallization.

3. Acetate Buffers

- Composition – Acetic acid (CH ƒCOOH) and sodium acetate (CH ƒCOONa).
- Typical pH Range – 3.5 to 5.5.
- Applications – Food preservation, histology staining, and certain analytical techniques.

4. Citrate Buffers

- Composition – Citric acid and sodium citrate.
- Typical pH Range – 3.0 to 6.2.
- Applications – Enzyme assays, pharmaceutical formulations, and chromatography.

5. Glycine-HCl Buffer

- Composition – Glycine and hydrochloric acid.
- Typical pH Range – 2.4 to 3.4.
- Applications – Protein electrophoresis, pH adjustments in cell culture, and analytical chemistry.

6. MOPS (3-(N-Morpholino)propanesulfonic Acid) Buffer

- Composition – MOPS and a suitable base (often NaOH).
- Typical pH Range – 6.5 to 7.9.
- Applications – Biochemical assays, cell biology, and microbiology.

7. HEPES (4-(2-Hydroxyethyl)-1-piperazineethanesulfonic Acid) Buffer

- Composition – HEPES and a base such as NaOH.
- Typical pH Range – 6.8 to 8.2.
- Applications – Cell culture, electrophysiology, and protein stability studies.

8. Bis-Tris Buffer

- Composition – Bis-Tris (bis(2-hydroxyethyl)imidazoline) and a base.
- Typical pH Range – 5.8 to 7.2.
- Applications – Protein crystallization, enzyme assays, and biophysical studies.

9. MOPS–NaOH Buffer

- Composition – MOPS and sodium hydroxide.
- Typical pH Range – 6.5 to 7.9.
- Applications – Similar to MOPS buffer, used in biochemical and microbiological work.

10. Sodium Bicarbonate Buffer

- Composition – Sodium bicarbonate (NaHCO ƒ) and water.
- Typical pH Range – 7.2 to 8.3.
- Applications – Cell culture media, pH adjustment in pharmaceutical formulations, and environmental studies.

11. Borate Buffer

- Composition – Boric acid (H ƒBO ƒ) and sodium hydroxide.
- Typical pH Range – 8.0 to 10.0.
- Applications – Protein chemistry, DNA/RNA manipulation, and analytical chemistry.

12. Carbonate Buffer

- Composition – Sodium carbonate (Na ,CO ƒ) and sodium bicarbonate (NaHCO ƒ).
- Typical pH Range – 8.3 to 9.6.
- Applications – Water treatment, pH stabilization in industrial processes, and biochemical assays.

13. TAPS (N-Tris(hydroxymethyl)methyl-3-aminopropanesulfonic Acid) Buffer

- Composition – TAPS and a base.
- Typical pH Range – 7.8 to 9.5.
- Applications – Protein studies, electrophoresis, and enzyme kinetics.

14. TES (N-Tris(hydroxymethyl)methyl-2-aminoethanesulfonic Acid) Buffer

- Composition – TES and a base.
- Typical pH Range – 6.1 to 7.5.
- Applications – Cell culture, molecular biology, and biochemical assays.

15. PIPES (piperazine-N,N 2-bis(2-ethanesulfonic acid)) Buffer

- Composition – PIPES and a base.
- Typical pH Range – 6.1 to 7.5.
- Applications – Protein crystallization, electrophoresis, and enzyme assays.

16. CAPS (N-Cyclohexyl-3-aminopropanesulfonic Acid) Buffer

- Composition – CAPS and a base.
- Typical pH Range – 10.0 to 11.0.
- Applications – Enzyme assays, protein studies, and biochemistry.

17. Good''s Buffers (General Overview)

Good’s buffers are a family of zwitterionic buffers designed to have minimal interference with biochemical processes. Some well-known members include:

- HEPES – pH 7.4
- HEPES – pH 7.0
- HEPES – pH 8.0
- Hepes – pH 6.8
- Hepes – pH 6.5
- HEPES – pH 8.2
- HEPES – pH 9.0
- HEPES – pH 5.6
- HEPES – pH 5.2
- HEPES – pH 4.5
- HEPES – pH 4.0
- HEPES – pH 3.5

18. Biological Buffers

- Phosphate-Buffered Saline (PBS) – Widely used in cell biology.
- Tris-EDTA (TTE) – Used in DNA purification.
- HEPES-NaOH – Common in protein studies.

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