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Buffers are prepared in pharmacies or by drug manufacturers. They adjust the pH of aqueous solutions for applications that require predictable stability and best clinical outcomes. From a pharmacological perspective, it is important to control the pH of a solution to minimize drug degradation, to improve patient comfort and compliance, and to improve the efficacy of delivery. Buffer solutions are able to resist a significant change in pH when a limited concentration of acid or base is added to them. The pH of a solution is defined as the negative logarithm of the molar hydrogen ion concentration. The most important characteristic of a buffer solution is its pH. These solutions are generally clear liquids prescribed by physicians and administered topically or intravenously by trained hospital personnel. Buffer solutions are able to resist a significant change in pH when a limited concentration of acid or base is added to them. The most important characteristic of a buffer solution is its pH. These solutions are generally clear liquids prescribed by physicians and administered topically or intravenously by trained hospital personnel. Mechanisms of Action A buffer solution contains an acid and its conjugate base, or a base and its conjugate acid. A strong acid loses a proton easily, and hence the conjugate base of a strong acid is a weak base. The most important characteristic of a buffer solution is the pH, which can be calculated using the Henderson-Hasselbalch equation, and its buffer capacity—the amount of acid or base that can be added without significant pH changes—which can be calculated from the van Slyke equation. A buffer solution contains an acid and its conjugate base, or a base and its conjugate acid. A strong acid loses a proton easily, and hence the conjugate base of a strong acid is a weak base. The primary purpose and importance of buffers in pharmacy is to protect pharmaceutical preparations from any sudden change in pH even when limited concentrations of acid or base are added. So, the osmotic pressure of a solution will be affected not only by the drug but also by any buffer compounds that are included in the formulation. After these compounds have been added, it is still possible that the solution will not be isotonic. The pharmacist calculates the isotonicity, since isotonicity is a property of the number of particles in solution. So, the osmotic pressure of a solution will be affected not only by the drug but also by any buffer compounds that are included in the formulation. Applications Buffered solutions given intravenously have very few adverse effects, as the body adjusts naturally to slight changes in the normal blood pH of 7.4. In pharmaceutical formulation for other applications, it is important to avoid large changes in the osmotic pressure across a cellular membrane. Thus, when buffered isotonic solutions are made for eyes, soft tissues, nasal cavities, and anal or vaginal cavity applications, special considerations of isotonicity arise to avoid complications. A buffered isotonic solution is prepared and administered that will have the same solute concentration as that in the biological fluid it contacts. Buffered solutions given intravenously have very few adverse effects, as the body adjusts naturally to slight changes in the normal blood pH of 7.4. Most buffers in pharmacy are manufactured by companies such as Baxter and Abbott Laboratories. However, many occasions still arise in the pharmacy to calculate and prepare isotonic buffer solutions. 2. Pharmacists must draw on their knowledge of anatomy, physiology, mathematics, chemistry and other sciences to prepare the appropriate admixture for beneficial patient outcomes. In Vivo Biologic Buffer System, Lacrimal Fluids, Urine, Preparations for the eye (i.e., ophthalmic preparations). In creams and ointments, in the blood, pH is maintained at approximately 7.4. As buffers in the plasma, carbonic acid and bicarbonate, as well as acid/alkali sodium salts of phosphoric acid, are present. In the blood, plasma proteins, which act as acids, can combine with bases to act as buffers. Erythrocytes consist of two buffer systems: hemoglobin and oxyhemoglobin, and acidic, alkaline potassium salts of phosphoric acid. When carbonic acid, at body temperature and ionic strength 0.16, is ionized in the plasma, the dissociation exponent pK1 is about 6.1. Carbonic acid and bicarbonate buffer equation for blood is. Where [H2CO3] indicates the concentration of CO2 present in the bloodstream as H2CO3. The balance of bicarbonate and carbonic acid in blood plasma with a pH of 7.4 is as follows: $\text{Ort} = \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} = \frac{0.16}{[\text{H}_2\text{CO}_3]}$. It has been found that lacrimal fluid, also known as tears, can be diluted at 1:15 with neutral distilled water. There is a pH range of 7 to 8 or slightly above in tears, ranging from 7.4 to 7.4. The cornea is generally thought to be unaffected by eye drops with a pH range from 4 to 10. The discomfort will be felt below pH 6.6 and the tears will flow above pH 9.0. Normal 24-hour urine collections of adults have a pH averaging about 6.7; they may be as low as 4.5 or as high as 7.8. Whenever urine pH falls below a normal level, hydrogen ions are excreted by the kidneys. The kidneys retain hydrogen ions in urine that have a pH above 7.4 to return the pH to a normal value. As part of the formulation of ophthalmic solutions, buffer solutions are often used in the pharmaceutical industry. The market today offers a variety of buffer solutions. Known as PBS, phosphate-buffered saline is a common biological buffer. In phosphate-buffered saline, sodium chloride (NaCl) and sodium phosphate (Na2PO4) are combined to produce NaCl. Additionally, it may contain potassium chloride (KCl), calcium chloride (CaCl2), and magnesium sulfate (MgSO4). In the field of pharmacy, buffers are widely used as ingredients in most pharmaceutical formulations so that the pH of the product is adjusted to the level required for the product's maximum stability. A parenteral preparation (i.e., an injection) contains: If parenteral preparations are being administered, it is very important to consider the pH since large deviations of pH can have serious consequences. It is recommended that parenteral products have a pH of 7.4, which is blood's pH. Most commonly, acetate, phosphate, citrate, and glutamate are used as buffers in parenteral products (injections). Preparations for the eye (i.e., ophthalmic preparations): The pH range of lacrimal fluid (eye fluid) is generally maintained by buffers in ophthalmic preparations. Although lacrimal fluid has a pH between 7 and 8, it has a good buffering capacity and can tolerate preparations with pH values between 3.5 and 10.5 without causing discomfort. A rise outside this range (i.e., 3.5 - 10.5) may result in other complications. Most ophthalmic preparations contain a buffering agent such as borate, carbonate, or phosphate. In creams and ointments: A buffer is used to ensure the stability of topical products (which are applied to the skin such as ointments). Among the most common buffers found in creams and ointments are citric acid and its salts and phosphoric acid. Developing a new buffer should be facilitated by following the steps below. The weak acid should have a pKa that approximates that of the pH at which the buffer should be used. Calculations involving pH within the range of 4 to 10 can be approximated using the buffer equation. Use it to determine the concentration of salt and weak acid required to reach the desired pH. Obtain a buffer capacity that is appropriate by considering the individual buffer salt and acid concentrations. It is usually sufficient to use a concentration of 0.05 to 0.5 M and to use a buffer with a capacity of 0.01 to 0.1. In addition to chemical availability, sterility of the final solution, stability of a drug and buffer during aging, cost of materials, and lack of toxicity are also important considerations in selecting a pharmaceutical buffer. For instance, a borate buffer, being toxic, cannot be used as a stabilizer for parenteral or oral administration. Determining the buffer capacity and pH of the completed buffered solution with a pH meter. In some cases, pH papers can also be used as a gauge for determining buffer capacity and pH. pH can sometimes differ from the experimental value when the electrolyte concentration is high, especially when using the buffer equation. It is reasonable to expect this to occur when the activity coefficient is not taken into consideration, and this emphasizes the need to perform the actual determination. There is often confusion between the terms shelf life and stability. The stability of a pH buffer refers to how long the buffer can maintain its accuracy. It takes pH buffer solutions between 24 and 60 months (2 to 5 years) before they expire. The pH buffer has been assumed to remain unopened for this period and to have remained out of adverse conditions (Example - excessive temperature). Get subject wise printable pdf Notes View Here Visitors are also reading: Buffers are critical in maintaining optimal pH conditions in pharmaceutical and biological systems. The stability of drug formulations, enzymatic reactions, and physiological processes relies on the precise control of pH. Understanding the applications of buffers in these systems is essential for drug development, medical research, and various healthcare-related processes. 1. Drug Formulation Stability: API Stability: Active Pharmaceutical Ingredients (APIs) often have specific pH ranges for stability. Buffers help maintain the desired pH, preventing degradation and enhancing the shelf life of pharmaceutical products. Bioavailability: Buffers can influence the stability and absorption of drugs, impacting their bioavailability and therapeutic effectiveness. 2. Parenteral Formulations: Injections and Infusions: Buffers are crucial in parenteral formulations to maintain the pH within a physiologically acceptable range, preventing pain at the injection site and ensuring the stability of the drug. 3. Biotechnological Applications: Biopharmaceuticals: Buffer systems are employed to produce and store biopharmaceuticals, such as monoclonal antibodies and vaccines, to maintain stability and efficacy. 4. Analytical Techniques: Chromatography: Buffers are used in High-Performance Liquid Chromatography (HPLC) and other analytical techniques to maintain the stability of analytes and optimize separation. 5. Buffer Selection: pH Control: Choosing the right buffer system allows for precise pH control, ensuring the compatibility of drug components and minimizing side effects. 1. Blood pH Regulation: Bicarbonate System: The bicarbonate ion (HCO3-) acts as a buffer in blood, maintaining a pH of around 7.4. This is crucial for enzymatic activity and overall cellular function. 2. Intracellular pH Control: Cellular Buffers: Biological systems utilize buffers to regulate the intracellular pH, ensuring an environment conducive to enzymatic reactions and cellular processes. 3. Enzymatic Activity: Enzyme Function: Buffers stabilize the pH and the activities of enzymes, optimizing their function. 4. Cell Culture and Bioprocessing: Cell Viability: In cell culture, buffers help maintain the pH of the growth medium, facilitating the activity of digestive enzymes. Urine Buffers: The role of buffers in urine pH, aiding in the excretion of acids and bases. Buffers are pivotal in maintaining pH stability in pharmaceutical and biological systems. In pharmaceuticals, they contribute to drug stability, formulation efficacy, and analytical accuracy. In biological systems, buffers are essential for cellular processes, enzymatic activity, and maintaining physiological conditions. A deep understanding of buffer systems is crucial for developing effective drugs, biopharmaceuticals and advancing medical and biological research. 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