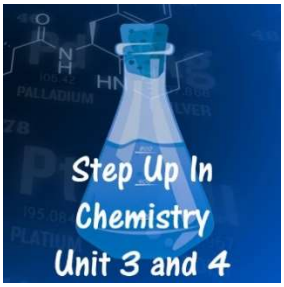
2.4 Buffers Problems

Problems Worksheet



1. What is a buffer solution and what does a buffer do?

2. Acetic acid is a weak acid which can be used to form a buffer solution.
    a. How would a buffer solution be prepared using 0.1 mol.L^{-1} acetic acid? What else would be required?

    b. Write a chemical equation for the buffer solution.

    c. Will this buffer be acidic or alkaline?

3. A weak base can also be used to produce a buffer.
    a. Explain how a buffer could be produced with ammonia and ammonium ion.

    b. Write an equation for the buffer.

    c. Is the buffer likely to be acidic or alkaline?

4. Using the acetic acid buffer as an example and including any relevant equations, explain how a buffer resists changes in pH when:
    a. Small amounts of acid are added,

    b. Small amounts of base are added.

5. Matthew is performing an experiment to show that a buffer is more resistant to pH changes than pure water. He has two beakers containing 50 mL of distilled water, and two beakers containing 50 mL of buffer solution.

    a. Calculate the pH of the 50 mL of water after 1.00 mL of 1.0 mol.L^{-1} HCl is added.

    b. Calculate the pH of the 50 mL of water after 1.00 mL of 1.0 mol.L^{-1} NaOH is added.

    c. He finds that the change in pH is almost insignificant when he adds the same amount of acid and or base to 50 mL samples of his H_2CO_3 and HCO_3^- buffer solution. Explain the observations.

6. Ollie wishes to make a buffer with a low pH to help him with his chemistry experiment. He plans to use HCl and a salt of its conjugate base, NaCl. Explain whether or not his procedure will be effective as a buffer.

7. Consider the following buffer solutions:

   Solution 1: 1.0 mol.L^{-1} H_2CO_3 and 1.0 mol.L^{-1} HCO_3^-
   Solution 2: 0.1 mol.L^{-1} CH_3COOH and 0.1 mol.L^{-1} CH_3COO^-

   a. Explain what is meant by buffering capacity and describe how can it be maximised.

   b. How would the buffering capacity of solution 1 compare with solution 2?

8. An acetic acid buffer is produced to have a concentration of 0.1 mol.L^{-1} of CH_3COOH and only 0.05 mol.L^{-1} of CH_3COO^-. Explain how this would affect the buffering capacity of the system. Would it be useful as a buffer?

9. Aaron's swimming pool has been neglected over the winter and he needs to improve its condition in preparation for the warmer weather approaching. He tests the pool water and finds it to have a pH of 8.40.
    a. Assuming no other reactions take place, calculate what volume of 12.0 $mol.L^{-1}$ HCl he needs to reduce the pH to its recommended level of 7.4 if the pool contains 2.00×10^4 L of water.

    b. Aaron has performed the same calculation and adds the acid to the swimming pool. He tests the water a short time later and find that the pH has barely changed. After properly reading the instructions on his pool chlorine bottle, he finds that he is supposed to add about 250 mL to reduce the pH to the desired level. What could be the reason for the large volume required?

    c. One of the processes involved in chlorination in swimming pools is the equilibrium between hypochlorous acid and hypochlorite ion:

    $HOCl(aq) + H_2O(l) \rightleftharpoons OCl^-(aq) + H_3O^+(aq)$

    Explain how this system would work to keep the pH constant as the hydrochloric acid is added to the swimming pool.

10. Blood pH needs to be kept between a very narrow range of 7.35 to 7.45 in order for the body to remain in homeostasis. Death can occur if the pH increases or decreases by 1 unit.

    One of the buffers involved in keeping the pH of the blood constant involves plasma proteins. Proteins are made from amino acids, which are organic molecules that can donate or accept a proton depending on the pH of their surroundings. Glycine is an amino acid which is found in most blood proteins and the following equation shows how glycine responds when it is dissolved in an acidic or basic solution:

    $$\underset{\text{high pH}}{OCH_2OCNH_2^-} \rightleftharpoons HOCH_2OCNH_2 \rightleftharpoons \underset{\text{low pH}}{HOCH_2OCNH_3^+}$$

    Use these equations and your knowledge of buffers to explain how blood maintains a constant pH when acids and bases are produced in chemical reactions in the human body.