Understanding buffers

Use the learning object, *How do buffers work?* and information provided to help answer the following questions.

1. Explain the difference between strong and weak acids. (use screens 1 and 2)

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2. Using Le Chatelier's principle, predict what will happen if:

   a solution containing hydrogen ions is added to a solution of hydrochloric acid (use screens 3 and 4)

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   a solution containing hydrogen ions is added to a solution of hydrofluoric acid? (use screens 3 and 4)

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3. Explain how it is possible for a weak acid system to be in equilibrium while reactions still occur.

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4. Write an equation showing the addition of acetic acid to water. Include water molecules in the equation, and identify any conjugate acid/base pairs.

5. Which has a better buffering capacity: hydrochloric acid or hydrofluoric acid? Explain your answer. (Remember, a buffer is a substance that stabilises pH)

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6. Study steps one to five on screen 5. Compare the concentration of hydrogen ions to the initial concentration:

   a. as soon as the HCl has been added? (step 3)

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   b. after equilibrium has been re-established? (step 5)

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7. How does pH change during the reaction?

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8. Explain how HF could act as a buffer if a small amount of NaOH was added. Drawing diagrams may aid your explanation.

9. Study steps one to five on screen 7. How do the concentrations of each species in the buffer compare to initial concentrations:

   a. as soon as hydrogen ions are added? (step 3)

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   b. after equilibrium has been re-established? (step 5)

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10. How does pH change during the reaction? Is this different from what happens with pure hydrofluoric acid? (compare screens 7 and 5)

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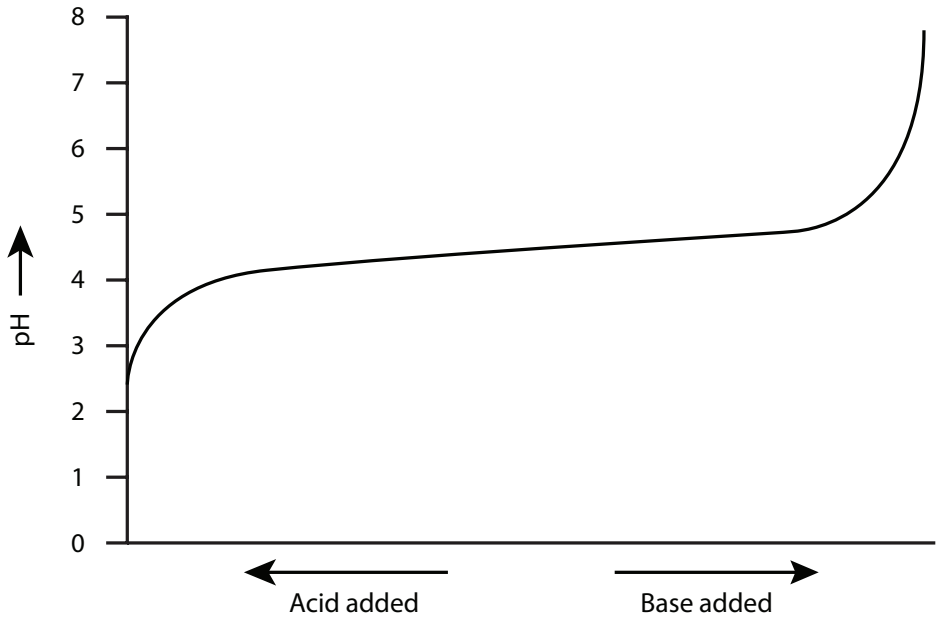
11. The following graph shows what happens to pH when a strong acid or a strong base is added to a weak acid. Explain the shape of this curve using your knowledge of buffering.



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12. Explain what the term 'buffering capacity' means at the molecular level.

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Part 2: Applying buffering principles to buffering in the human body

Our bodies require energy to carry out their daily functions. This energy is created in cells by the reaction of glucose and oxygen. Carbon dioxide and water are also produced, and they react further to produce hydrogen ions.

When we exercise, breathing rate increases to supply more oxygen to our cells. However, after a certain point it becomes difficult to provide enough oxygen in this way, and other chemical reactions that produce excess lactic acid occur. This increases the concentration of hydrogen ions in the blood, which causes pH to decrease. Normal blood pH is 7.4. Changes in this level can cause illness or death, so the body must have mechanisms in place to maintain constant pH. Blood plays a crucial role in this process.

Several buffering systems are present in the circulatory system. The most important of these is the carbonic acid/hydrogencarbonate buffer system:

$$H^+_{(aq)} + HCO^-_{3(aq)} \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons H_2O_{(l)} + CO_{2(g)}$$

13. This is a two-part equilibrium reaction. Which reaction is an acid/base reaction? Explain your answer.

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14. Draw diagrams to show how the buffering system in blood works, based on the animation in the learning object. Note that carbonic acid ionises rapidly to form water and carbon dioxide.

15. Use Le Chatelier's principle and the buffering equation above to explain why:

    a. A person breathes harder and exhales more carbon dioxide when they exercise vigorously.

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    b. The kidneys remove hydrogencarbonate ions when blood pH is too high for buffering alone to stabilise (this condition is called alkalosis).

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c. When a person hyperventilates the concentration of carbon dioxide in their blood decreases. Would this result in increased or decreased blood pH?

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16. It is important that the concentration of buffer in blood is high. Explain why.

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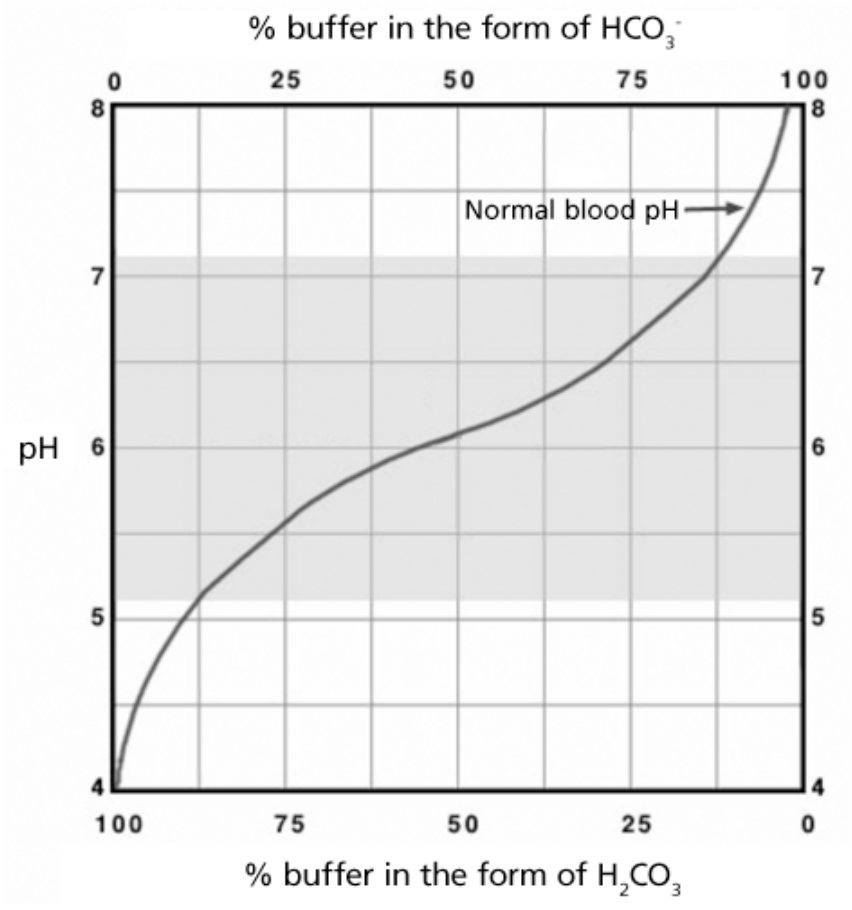
- The following diagram shows the buffer curve for the carbonic acid/hydrogencarbonate equilibrium reaction stated previously.



17. Over what pH range is hydrogencarbonate a good buffer?

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18. The pH of blood is normally 7.4, which is outside the buffering region of HCO_3^- shown in the diagram above. Explain why it is still able to work as a buffer in the human body. (Think about differences between applying Le Chatelier's principle to a laboratory experiment and the human body.)

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