# 24 Buffers

A **buffer** is a solution that resists rapid changes in pH when an acid or base is added. Control of pH is very important in living systems.

A buffer is usually made by mixing together a **weak acid and the salt of that acid.** A buffer can also be made using **a weak base and the salt of that base.** Examples of buffers are:

- acetic acid ($CH_3COOH$) and sodium acetate ($CH_3COONa$)
- carbonic acid ($H_2CO_3$) and sodium bicarbonate ($NaHCO_3$)
- ammonia ($NH_3$) and ammonium chloride ($NH_4Cl$)

In a buffer, an equilibrium is established between the weak acid and its conjugate base, for example:

$$CH_3COOH(l) + H_2O(l) \Leftrightarrow H_3O^+(aq) + CH_3COO^-(aq)$$

When you add hydrogen ions (more acid) the equilibrium moves to the left to reduce the hydrogen ion concentration and minimise the change (Le Châtelier's principle). Hence the pH change is kept to a minimum.

When a base is added, the hydroxide ions combine with hydrogen ions and remove them from solution. The equilibrium then moves to the right to try and replace the hydrogen ions used up and thus minimise the change (Le Châtelier's principle). Again, there is little or no detectable change in pH.

In living things, the rate of chemical reactions is controlled by biological catalysts called enzymes. Each enzyme acts at a specific pH, so a slight change in pH can greatly affect the chemistry of living cells. pH must be controlled in living things and this control is achieved by buffering systems.

Blood is a buffered solution, containing carbonic acid and sodium bicarbonate. This allows its pH to stay constant at 7.4. Carbon dioxide dissolves in our blood, forming carbonic acid, a weak acid that ionises to form the hydrogen carbonate ion.

$$CO_2(g) + H_2O(l) \Leftrightarrow H_2CO_3(aq) \quad \text{..... (i)}$$

$$H_2CO_3(aq) \Leftrightarrow H^+(aq) + HCO_3^-(aq) \quad \text{..... (ii)}$$

If more $CO_2$ dissolves in blood, more $H^+$ ions will form. This would push the pH down, but the equilibrium moves to the left, minimising the change.

If the pH is tending to increase (not acidic enough) more carbonic acid molecules ionise and the equilibrium moves to the right to produce more hydrogen ions, again minimising the change.

Because carbonic acid is a weak acid, any increase or decrease in the amount of acid present only produces a very small change in hydrogen ion concentration and thus a very small change in pH.

## For You To Do

1. Identify which of the following pairs of chemicals would make a buffer when mixed. Justify your answer.
   (a) 0.2 mol hydrochloric acid and 0.2 mol sodium chloride
   (b) 0.34 mol ethanoic acid and 0.34 mol potassium ethanoate
   (c) 0.5 mol sodium hydroxide and 0.5 mol sodium nitrate
2. The pH of sea water is kept constant because a buffer system occurs involving $H_2CO_3$, $HCO_3^-$ ions and $CO_3^{2-}$ ions. Two of the reactions involved are:

   $OH^-(aq) + HCO_3^-(aq) \Leftrightarrow H_2O(l) + CO_3^{2-}(aq)$ .....(i)

   $H^+(aq) + HCO_3^-(aq) \Leftrightarrow H_2CO_3(aq)$ .....(ii)

   (a) If extra acid (extra $H^+$ ions) is added to sea water, what effect would this have on the two reactions above?
   (b) Outline the effect this addition of acid would have on the concentration of hydrogen carbonate ions in sea water.
3. (a) Outline the meaning of the term 'buffer'.
   (b) Qualitatively describe the effect of buffers with reference to a specific example in a natural system.
4. Hyperventilation occurs when a person breathes at a faster rate than normal and loses too much carbon dioxide from the lungs and thus from the blood.
   (a) Using equations, explain the effect of this on the $HCO_3^-$ buffer system in blood.
   (b) The treatment for hyperventilation is usually to get the patient to breathe in and out from the air in a paper bag. Justify the use of this treatment.
5. Explain the importance of buffer systems in the maintenance of blood pH after exercise.
6. A buffer commonly used in laboratories is a mixture of $NaH_2PO_4$ and $Na_2HPO_4$.
   (a) Using equations, assess its potential as a buffer system.
   (b) Identify an acid-base conjugate pair in your equations.
7. Check your knowledge with this quick quiz.
   (a) Name two chemicals you could mix to obtain a buffer.
   (b) Identify the two main chemicals that buffer blood.