

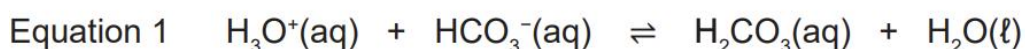
**Question 36****(20 marks)**

The ideal pH of human blood is 7.4. If the pH of a person's blood varies too much from this value, a serious condition can develop. If the pH is too low, it is called acidosis; if the pH is too high, it is called alkalosis. Death may occur if the pH drops below 6.8 or rises above 7.8.

One buffer system for maintaining acid-base balance in blood is the carbonic acid-hydrogencarbonate buffer.

During exercise, the muscles need more oxygen to produce energy. They produce carbon dioxide,  $\text{CO}_2$ , and hydronium ions,  $\text{H}_3\text{O}^+$ , which move from the muscles to the blood.

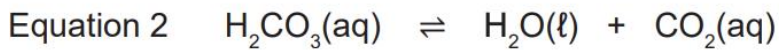
The relevant equilibrium equations for the carbonic acid-hydrogencarbonate buffer system are shown as follows.



- (a) Identify the **two** conjugate acid-base pairs on Equation 1 above, indicating clearly which is the acid and which is the base in each pairing. (2 marks)

- (b) Write the equilibrium constant expression for Equation 1. (2 marks)

Carbonic acid further reacts to form water and carbon dioxide as shown in Equation 2.



- (c) Combine Equations 1 and 2, to create an overall equation that shows the relationship between  $\text{HCO}_3^-(\text{aq})$  and  $\text{CO}_2(\text{aq})$ . (2 marks)

- (d) Identify the effect on the blood's pH when each of the following components are removed: carbon dioxide and hydrogencarbonate ions. (2 marks)

Component removed	Effect on pH (circle your answer)		
carbon dioxide	increase	decrease	no effect
hydrogencarbonate ions	increase	decrease	no effect

The buffering capacity of the carbonic acid-hydrogencarbonate is greatest when the pH is between 5.1 and 7.1.

- (e) State **two** conditions in terms of concentration that are necessary for this buffering capacity to be optimal. (2 marks)

One: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Two: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

When the pH of the blood is too high, the kidneys can remove hydrogencarbonate ions,  $\text{HCO}_3^-$ , from the blood.

- (f) Use Le Châtelier's Principle to demonstrate that the kidneys' action can help to prevent excessively high blood pH. (3 marks)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

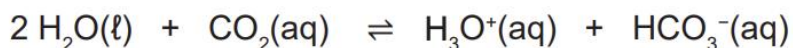
\_\_\_\_\_

\_\_\_\_\_

When inhaling, oxygen is taken into the lungs and transferred to the blood; when exhaling, carbon dioxide is expelled.

During hyperventilation (very rapid and deep breathing) more carbon dioxide is being expelled from the body than it can produce. This upsets the oxygen/carbon dioxide balance and can cause dizziness and fainting. Hyperventilating results in lowering the carbon dioxide concentration in the blood, which can affect the pH of the blood.

The equation shown below illustrates the formation of hydronium ions within the blood system.



A first-aid treatment for hyperventilation is the 'paper-bag treatment' whereby the patient breathes into a paper bag and so breathes back in the expelled breath, which contains a higher concentration of carbon dioxide.

- (g) State the effect of the 'paper-bag treatment' on the pH of the blood and explain why it is an effective treatment for hyperventilation. (3 marks)

---

---

---

---

---

---

Another contributor to a potential imbalance of blood pH is the formation of lactic acid. The chemical name for lactic acid is 2-hydroxypropanoic acid,  $C_3H_6O_3$ .

- (h) Draw the structural formula for lactic acid with **all** its functional groups circled and labelled. (4 marks)

