Marks

- Quinine is a natural product that has anti-malarial properties. It was originally extracted for therapeutic use from the bark of the cinchona tree, but is now synthesised by the pharmaceutical industry. Quinine is not very soluble in water and is generally administered as the more soluble hydrochloride salt ($C_{20}H_{24}N_2O_2 \cdot HCl$). The p$K_a$ of this salt is 4.32. What is the pH of a 0.053 M solution of quinine hydrochloride? **3**

As ascorbic acid is a weak acid, $[H_3O^+]$ must be calculated:

	acid	H_2O	$\rightleftharpoons$	H_3O^+	base
initial	**0.053**	**large**		**0**	**0**
change	**$-x$**	**negligible**		**$+x$**	**$+x$**
final	**$0.053 - x$**	**large**		**x**	**x**

The equilibrium constant K_a is given by:

$$K_a = \frac{[H_3O^+(aq)][base]}{[acid]} = \frac{x^2}{(0.053 - x)}$$

As pK_a = 4.32, $K_a = 10^{-4.32}$ and is very small, $0.053 - x \sim 0.053$ and hence:

$$x^2 = 0.053 \times (10^{-4.32}) \text{ or } x = 1.59 \times 10^{-3} \text{ M} = [H_3O^+(aq)]$$

Hence, the pH is given by:

$$pH = -\log_{10}[H_3O^+(aq)] = -\log_{10}[0.00159] = 2.80$$

Answer: **pH = 2.80**

- Use chemical equations to illustrate how $HPO_4^{2-}/H_2PO_4^-$ can act as a buffer. **2**

The $HPO_4^{2-}(aq)$ acts as a base and can take up added $H^+(aq)$:

$$HPO_4^{2-}(aq) + H_3O^+(aq) \rightarrow H_2PO_4^-(aq) + H_2O(l)$$

The $H_2PO_4^-(aq)$ acts as an acid and can take up added $OH^-(aq)$:

$$H_2PO_4^-(aq) + OH^-(aq) \rightarrow HPO_4^{2-}(aq) + H_2O(l)$$

The system thus has the capacity to maintain the pH.