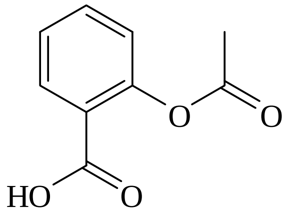
Marks 8

- The structure of common aspirin, acetylsalicylic acid, is shown below. It has a pK_a value of 3.5.



Calculate the pH of a solution in which one normal adult dose (0.65 g) is dissolved in 250 mL of water.

The chemical formula of acetylsalicylic acid is $C_9H_8O_4$. It has a molar mass of (9 × 12.01 (C) + 8 × 1.008 (H) + 4 × 16.00 (O)) g mol^{-1} = 180.154 g mol^{-1}.

The number of moles present corresponds to:

number of moles = mass / molar mass
= (0.65 g) / (180.154 g mol^{-1}) = 0.00361 mol

The concentration when this amount is dissolved in 250 mL of water is therefore:

[aspirin] = number of moles / volume
= (0.00361 mol) / (0.25 L) = 0.0144 M

As aspirin is a weak acid, $[H_3O^+]$ must be calculated using a reaction table:

	$C_9H_8O_4$	H_2O	$\rightleftharpoons$	H_3O^+	$C_9H_7O_4^-$
initial	**0.0144**	**large**		**0**	**0**
change	**-x**	**negligible**		**+x**	**+x**
final	**0.144 –x**	**large**		**x**	**x**

The equilibrium constant K_a is given by:

$$K_a = \frac{[H_3O^+][C_9H_7O_4^-]}{[C_9H_7O_4]} = \frac{x^2}{0.0144-x}$$

As pK_a = -log$_{10}K_a$, $K_a = 10^{-3.5}$ and is very small, 0.0144 – x ~ 0.0144 and hence:

$x^2 = 0.0144 \times 10^{-3.5}$ **or** $x = 2.1 \times 10^{-3}$ M = $[H_3O^+]$

Hence, the pH is given by:

$$\text{pH} = -\log_{10}[H_3O^+] = -\log_{10}(2.1 \times 10^{-3}) = 2.7$$

Answer: **2.7**

If blood has a pH of 7.4, what percentage of aspirin is present in the deprotonated form in a solution consisting of one normal adult dose in 250 mL of blood?

Using the Henderson – Hasselbalch equation,

$$\mathbf{pH = p}\boldsymbol{K}_{\mathbf{a}}\mathbf{ + log}\frac{[\mathbf{base}]}{[\mathbf{acid}]}$$

At a pH of 7.4

$$\mathbf{7.4 = 3.5 + log}\frac{[\mathbf{base}]}{[\mathbf{acid}]} \quad \mathbf{so} \quad \frac{[\mathbf{base}]}{[\mathbf{acid}]} = \mathbf{10^{3.9} = 7900}$$

The deprotonated, conjugate base form completely dominates at this pH.

Answer: **100% base**

Solutions of aspirin are unstable due to hydrolysis. If 0.26 g of a normal adult dose remains after 4 hours, what is the half-life of aspirin?

The number of moles present after 4 hours corresponds to:

number of moles = mass / molar mass
= (0.26 g) / (180.154 g mol^{-1}) = 0.00144 mol

The concentration when this amount is dissolved in 250 mL of water is therefore:

[aspirin] = number of moles / volume
= (0.00144 mol) / (0.25 L) = 0.00577 M

The amount present after time t is related to the amount initially present through the equation:

$$\mathbf{ln[A] = ln[A]_0 -} \boldsymbol{kt}$$

From above, $[A]_0$ = 0.0144 M. As [A] = 0.00577 M with t = 4 hours:

$$\mathbf{ln(0.00577) = ln(0.0144) –} \boldsymbol{k} \times \mathbf{4}$$

$$\boldsymbol{k} \mathbf{= 0.23}$$

Finally, the half life, $t_{1/2}$, is given by

$$\boldsymbol{t_{1/2}} \mathbf{= ln2 /} \boldsymbol{k} \mathbf{= 3\ hours}$$

Answer: **3 hours**