Marks 7

- Uric acid, $C_5H_5N_4O_3$, is a weak diprotic acid with a low solubility of 70 mg L^{-1}. The extremely painful inflammation known as gout occurs when crystals of uric acid are deposited in the joints. Given that the pH of a saturated solution of uric acid is 4.58, calculate the pK_{a1} of uric acid at 25 °C?

As pH = $-\log_{10}([H_3O^+(aq)])$ 4.58, $[H_3O^+(aq)] = 10^{4.58} = 2.63 \times 10^{-5}$ M.

The molar mass of uric acid is:

$$((5\times12.01\ (C)) + (5\times1.008\ (H)) + (4\times14.01\ (N)) + (3\times16.00\ (O)))\ g\ mol^{-1} = 169.13\ g\ mol^{-1}$$

A one litre solution contains 70 mg corresponding to

$$\text{number of moles} = \frac{(70\times10^{-3}\ g)}{(169.13\ g\ mol^{-1})} = 4.1\times10^{-4}\ mol.$$

For this weak acid, the reaction table is:

	$C_5H_5N_4O_3$	H_2O	$\rightleftharpoons$	H_3O^+	$C_5H_4N_4O_3^-$
initial	4.1×10^{-4}	large		0	0
final	$(4.1\times10^{-4}) - (2.63\times10^{-5})$	large		2.63×10^{-5}	2.63×10^{-5}

The equilibrium constant K_{a1} is given by:

$$K_{a1} = \frac{[H_3O^+(aq)][C_5H_4N_4O_3^-(aq)]}{[C_5H_5N_4O_3(aq)]} = \frac{(2.63\times10^{-5})\times(2.63\times10^{-5})}{(3.9\times10^{-4})} = 1.8\times10^{-6}$$

Hence, $pK_{a1} = -\log_{10}K_{a1} = -\log_{10}(1.8\times10^{-6}) = 5.7$

Answer: **$pK_{a1} = 5.7$**

The monosodium salt of uric acid is slightly more soluble, 8×10^{-4} g mL^{-1}. Calculate the solubility product constant, K_{sp}, of sodium urate at 25 °C. Assume no hydrolysis of the urate ion occurs.

The formula mass of the monosodium salt, $NaC_5H_4N_4O_3$ is 22.99 (Na) + (5×12.01 (C)) + (4×1.008 (H)) + (4×14.01 (N)) + (3×16.00 (O)) = 191.112. The molar solubility is:

$$\text{molar solubility} = \frac{\text{solubility}}{\text{formula mass}} = \frac{(8\times10^{-4}\ g\ mL^{-1})}{(191.112\ g\ mol^{-1})}$$
$$= = 4\times10^{-6}\ mol\ mL^{-1} = 4\times10^{-3}\ M$$

Hence, $K_{sp} = [Na^+(aq)][C_5H_4N_4O_3^-(aq)] = (4\times10^{-3})\times(4\times10^{-3}) = 2\times10^{-5}$

Answer: **$K_{sp} = 2\times10^{-5}$**

ANSWER CONTIUNES ON THE NEXT PAGE

Suggest a possible reason why the pH of blood plasma remains near 7.4 even when saturated with uric acid.

Blood is buffered by a CO_3^{2-} / HCO_3^- buffering system which resists changes in pH.