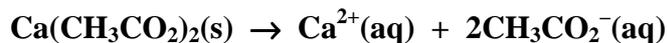


- Write the balanced chemical equation for the dissolution of solid $\text{Ca}(\text{CH}_3\text{CO}_2)_2$ in water.

Marks
6



What is the pH of a solution that has 158.2 g of $\text{Ca}(\text{CH}_3\text{CO}_2)_2$ dissolved in 1.000 L of water? The $\text{p}K_a$ of acetic acid, CH_3COOH , is 4.76.

The molar mass of $\text{Ca}(\text{CH}_3\text{CO}_2)_2$ is:

$$\begin{aligned} \text{molar mass} &= (40.08 (\text{Ca}) + 4 \times 12.01 (\text{C}) + 6 \times 1.008 (\text{H}) + 4 \times 16.00 (\text{O})) \text{ g mol}^{-1} \\ &= 158.168 \text{ g mol}^{-1} \end{aligned}$$

Thus, 158.2 g corresponds to:

$$\text{number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{158.2 \text{ g}}{158.168 \text{ g mol}^{-1}} = 1.000 \text{ mol}$$

When $\text{Ca}(\text{CH}_3\text{CO}_2)_2$ is dissolved, it produces $\text{Ca}^{2+}(\text{aq}) + 2\text{CH}_3\text{CO}_2^-$. Hence, if 1.000 mol of $\text{Ca}(\text{CH}_3\text{CO}_2)_2$ is dissolved in 1.0 L, $[\text{CH}_3\text{CO}_2^-]_{\text{initial}} = 2.000 \text{ M}$.

As CH_3CO_2^- is a weak base, $[\text{CH}_3\text{CO}_2^-]$ must be calculated by considering the equilibrium:

	CH_3CO_2^-	H_2O	\rightleftharpoons	$\text{CH}_3\text{CO}_2\text{H}$	OH^-
initial	2.000	large		0	0
change	-x	negligible		+x	+x
final	$2.000 - x$	large		x	x

The equilibrium constant K_b is given by:

$$K_b = \frac{[\text{CH}_3\text{CO}_2\text{H}][\text{OH}^-]}{[\text{CH}_3\text{CO}_2^-]} = \frac{x^2}{(2.000 - x)}$$

For an acid and its conjugate base:

$$\text{p}K_a + \text{p}K_b = 14.00 \text{ so } \text{p}K_b = 14.00 - 4.76 = 9.24$$

As $\text{p}K_b = 9.24$, $K_b = 10^{-9.24}$. K_b is very small so $2.000 - x \sim 2.000$ and hence:

$$x^2 = 2.000 \times 10^{-9.24} \text{ or } x = 0.0000393 \text{ M} = [\text{OH}^-]$$

Hence, the pOH is given by:

$$\text{pOH} = -\log_{10}[\text{OH}^-] = \log_{10}[0.0000393] = 4.47$$

Finally, $\text{pH} + \text{pOH} = 14.00$ so

$$\text{pH} = 14.000 - 4.47 = 9.53$$

$$\text{pH} = 9.53$$

ANSWER CONTINUES ON THE NEXT PAGE

Calculate the pH of this solution after the addition of 0.250 mol of HCl gas?

The solution contain 2.000 mol of CH_3CO_2^- . This will react with 0.250 mol of $\text{HCl}(\text{g})$ to produce 0.250 mol of $\text{CH}_3\text{CO}_2\text{H}$, leaving $(2.000 - 0.250)$ mol = 1.750 mol of CH_3CO_2^- in unreacted.

As the solution has a volume of 1.000 L, $[\text{CH}_3\text{CO}_2\text{H}] = 0.250$ M and $[\text{CH}_3\text{CO}_2^-] = 1.750$ M.

The solution contains a weak acid and its conjugate base. The pH of this buffer solution can be calculated using the Henderson-Hasselbalch equation;

$$\text{pH} = \text{p}K_{\text{a}} + \log \frac{[\text{base}]}{[\text{acid}]} = 4.76 + \log \frac{1.750}{0.250} = 5.61$$

$$\text{pH} = 5.61$$