Marks

- The formulation of a pharmaceutical to be delivered by injection includes sodium chloride to make it isotonic with blood plasma. Why is this necessary? **2**

An isotonic solution has the same concentration of particles as in cell fluid so water particles leave the cell at the same rate that they enter it and there is no change in the osmotic pressure. A non-isotonic solution would lead to a change in the osmotic pressure and hence a change in the cell volume.

- A solution of volume 2.00 L was prepared by mixing equal volumes of nitric acid (0.10 M) and sulfuric acid (0.10 M). To this, sodium hydroxide (10.0 g) was added. Assuming no volume change, what is the pH of the final solution? **3**

Nitric acid, HNO_3, dissociates completely to give 1 mol of H^+(aq) for every mole of acid. The number of moles in 1.00 L of a 0.10 M solution of HNO_3(aq) is:

$$n(H^+(aq)) = \text{volume} \times \text{concentration} = 1.00 \text{ L} \times 0.10 \text{ M} = 0.100 \text{ mol}$$

Sulfuric acid, H_2SO_4, dissociates completely to give 2 mol of H^+(aq) for every mole of acid. The number of moles in 1.00 L of a 0.10 M solution of H_2SO_4(aq) is:

$$n(H^+(aq)) = 2 \times 1.00 \times 0.10 = 0.200 \text{ mol}$$

The total number of moles of H^+(aq) is thus (0.100 + 0.200) mol = 0.300 mol.

The formula mass of NaOH is 22.99 (Na) + 16.00 (O) + 1.008 (H) g mol^{-1} = 39.998 g mol^{-1} so 10.0 g contains:

$$n(OH^-(aq)) = \frac{\text{mass}}{\text{formula mass}} = \frac{10.0 \text{ g}}{39.998 \text{ g mol}^{-1}} = 0.250 \text{ mol}$$

The number of moles of H^+(aq) after the addition of NaOH is thus:

$$n(H^+(aq)) = (0.300 - 0.250) \text{ mol} = 0.050 \text{ mol}$$

This amount is dissolved in a volume of 2.00 L so the final concentration is:

$$[H^+(aq)] = \frac{\text{number of moles}}{\text{volume}} = \frac{0.050 \text{ mol}}{2.00 \text{ L}} = 0.0250 \text{ M}$$

As pH = $-\log_{10}([H^+(aq)]$,

$$pH = -\log_{10}(0.0250) = 1.6$$

pH = **1.6**

ANSWER CONTIUNES ON THE NEXT PAGE

- Acetic acid (100 mL, 0.20 M) is mixed with solid sodium hydroxide (0.010 mol). Calculate the final pH of the solution. pK_a of acetic acid = 4.76 **3**

Assuming that the addition of solid sodium hydroxide causes no volume change, the initial [OH^-(aq)] is:

$$\textbf{concentration} = \frac{\textbf{number of moles}}{\textbf{volume}} = \frac{0.010\,\textbf{mol}}{(100/1000)\,\textbf{L}} = 0.10\,\textbf{M}$$

Acetic acid and sodium hydroxide react together in a 1:1 ratio:

	CH_3COOH	OH^-	$\rightleftharpoons$	CH_3COO^-	H_2O
initial	**0.20**	**0.10**		**0**	**large**
final	**(0.20 – 0.10) = 0.10**	**0**		**0.10**	**large**

The solution contains an acid and its conjugate base so the Henderson-Hasselbalch equation can be used:

$$pH = pK_a + \log_{10}\left(\frac{[base]}{[acid]}\right) = 4.76 + \log_{10}\left(\frac{[CH_3COO^-]}{[CH_3COOH]}\right)$$

As [acid] = [base], $\log_{10}\left(\frac{[base]}{[acid]}\right) = \log_{10}(1) = 0$ **and so**

$$pH = pK_a = 4.76$$

pH = **4.76**