Marks 4

- Oral rehydration therapy (ORT) is a simple low-cost treatment that replaces fluid and electrolytes lost by sufferers of diarrhoea. To make the solution for ORT, 3.5 g NaCl, 2.9 g sodium citrate (which contains 1 citrate^{3-} and 3 Na^+ ions and has a molar mass of 258 g mol^{-1}), 1.5 g KCl and 20.0 g glucose ($C_6H_{12}O_6$) are dissolved in water to make 1.0 L of solution. What is the osmotic pressure (in mmHg) of this solution at body temperature (37 °C)?

The osmotic pressure, Π, is given by $\Pi = i \times MRT$ where M is the molarity of the solution and i is the amount (mol) of particles in solution divided by the amount (mol) of dissolved solute. For this solution, the contributions from each dissolved species are summed, $\Pi = \Sigma\ (i \times MRT)$.

As NaCl dissolves to give two particles, $Na^+ + Cl^-$, $i_{NaCl} = 2$. The formula mass of NaCl is 22.99 (Na) + 35.45 (Cl) g mol^{-1} = 58.44 g mol^{-1} so 3.5 g contains:

$$n_{NaCl} = \frac{\text{mass}}{\text{formula mass}} = \frac{3.5\,\text{g}}{58.44\,\text{g mol}^{-1}} = 0.060\,\text{mol}$$

$$M_{NaCl} = \frac{n}{V} = \frac{0.060\,\text{mol}}{1.0\,\text{L}} = 0.060\,\text{M}$$

As sodium citrate dissolves to give four particles, $3Na^+ + \text{citrate}^{3-}$, $i_{\text{sodium citrate}} = 4$. The formula mass of sodium citrate is 258 g mol^{-1} so 2.9 g contains:

$$n_{\text{sodium citrate}} = \frac{2.9\,\text{g}}{258\,\text{g mol}^{-1}} = 0.011\,\text{mol}$$

$$M_{\text{sodium citrate}} = \frac{0.011\,\text{mol}}{1.0\,\text{L}} = 0.011\,\text{M}$$

As KCl dissolves to give two particles, $K^+ + Cl^-$, $i_{KCl} = 2$. The formula mass of KCl is 39.10 (K) + 35.45 (Cl) g mol^{-1} = 74.55 g mol so 1.5 g contains:

$$n_{KCl} = \frac{1.5\,\text{g}}{74.55\,\text{g mol}^{-1}} = 0.020\,\text{mol}$$

$$\text{M}_{KCl} = \frac{0.020\,\text{mol}}{1.0\,\text{L}} = 0.020\,\text{M}$$

As glucose dissolves without dissociating, $i_{\text{glucose}} = 1$. The molar mass of glucose is (6 × 12.01 (C)) + (12 × 1.008 (H)) + (6 × 16.00 (O)) g mol^{-1} = 180.156 g mol^{-1}. 20.0 g contains:

$$n_{\text{glucose}} = \frac{20\,\text{g}}{180.156\,\text{g mol}^{-1}} = 0.11\,\text{mol}$$

$$M_{\text{glucose}} = \frac{0.11\,\text{mol}}{1.0\,\text{L}} = 0.11\,\text{M}$$

ANSWER CONTINUES ON THE PAGE

The total osmotic pressure is therefore:

$$\boldsymbol{\Pi} = \boldsymbol{\Pi}_{\text{NaCl}} + \boldsymbol{\Pi}_{\text{sodium citrate}} + \boldsymbol{\Pi}_{\text{KCl}} + \boldsymbol{\Pi}_{\text{glucose}}$$
$$= [(2\times0.060) + (4\times0.011)+(2\times0.020)+(1\times0.11)] \times (0.08206) \times (37.+ 273) \text{ atm}$$
$$= 8.0 \text{ atm}$$

As 1 atm = 760 mmHg, 8.0 atm = (8.0 × 760) = 6.1 × 10^3 mmHg

	Answer: **6.1 × 10^3 mmHg**

This pressure is about the same as the osmotic pressure of blood. The calorie content of the solution can be increased by adding either more glucose or a polymer of glucose. Which would be preferable? Give a brief reason.

The polymer would be preferable as it would cause little change in the osmotic pressure of the solution.