Marks
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- An aqueous solution with a volume of 10.0 mL contains 0.025 g of a purified protein of unknown molecular weight. The osmotic pressure of the solution was measured in an osmometer to be 0.0036 atm at 20.0 °C. Assuming ideal behaviour and no dissociation of the protein, estimate its molar mass in g mol^{-1}.

A pressure of 0.0036 atm corresponds to $(0.0036 \times 101.3 \times 10^3)$ Pa = 360 Pa. The osmotic pressure, Π, is related to the concentration of the solute through

$$\Pi = cRT$$

Hence:

$$c = \Pi / RT = 360 \text{ Pa} / ((8.314 \text{ Pa m}^3 \text{ mol}^{-1} \text{ K}^{-1})((20.0 + 273) \text{ K}))$$
$$= 0.15 \text{ mol m}^{-3} = 0.15 \times 10^{-3} \text{ mol L}^{-1}$$

The number of moles in 10.0 mL is therefore:

$$\text{number of moles} = \text{concentration} \times \text{volume}$$
$$= (0.15 \times 10^{-3} \text{ mol L}^{-1}) \times (0.0100 \text{ L}) = 1.5 \times 10^{-6} \text{ mol}$$

As this is the number of moles in 0.025 g, the molar mass is:

$$\text{molar mass} = \text{mass / number of moles}$$
$$= 0.025 \text{ g} / 1.5 \times 10^{-6} \text{ mol} = 17000 \text{ g mol}^{-1}$$

Answer: **17000 g mol^{-1}**