Calculate the osmotic pressure of a 0.25 M aqueous solution of sucrose, C\(_{12}\)H\(_{22}\)O\(_{11}\), at 37 °C.

The osmotic pressure for strong electrolyte solutions is given by:

\[ \Pi = i \times (cRT) \]

where \(i\) is the amount (mol) of particles in solution divided by the amount (mol) of dissolved solute. For 0.25 M sucrose, \(c = 0.25\) M and \(i = 1\). Hence,

\[ \Pi = (0.25 \times 1 \text{ mol L}^{-1}) \times RT \]
\[ = (0.25 \text{ mol L}^{-1}) \times (0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}) \times ((37 + 273) \text{ K}) = 6.4 \text{ atm} \]

Answer: 6.4 atm
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Answer: 6.4 atm
• Ammonia (NH$_3$) has a boiling point of –33 °C and phosphine (PH$_3$) has a boiling point of –83 °C. Explain the difference in these boiling points in terms of the intermolecular forces present.

Although PH$_3$ is a larger molecule with greater dispersion forces than ammonia, NH$_3$ has very polar N-H bonds leading to strong hydrogen bonding. This the dominant intermolecular force and results in a greater attraction between NH$_3$ molecules than there is between PH$_3$ molecules.
• A saline solution used for intravenous injections contains 900 mg of sodium chloride in 100 mL. What is the concentration of this sodium chloride solution?

The molar mass of NaCl is \( (22.99 \text{ (Na)} + 35.45 \text{ (Cl)}) \text{ g mol}^{-1} = 58.44 \text{ g mol}^{-1} \). The number of moles in 900 mg is therefore:

\[
\text{number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{900 \times 10^{-3} \text{ g}}{58.44 \text{ g mol}^{-1}} = 0.0154 \text{ mol}
\]

The concentration is therefore:

\[
\text{concentration} = \frac{\text{number of moles}}{\text{volume}} = \frac{0.0154 \text{ mol}}{0.100 L} = 0.154 \text{ mol L}^{-1}
\]

Answer: 0.154 M

What is the osmotic pressure of this solution at 37 °C?

The osmotic pressure for strong electrolyte solutions is given by:

\[
\Pi = i \times (cRT)
\]

where \( i \) is the amount (mol) of particles in solution divided by the amount (mol) of dissolved solute.

For 0.154 M NaCl, \( c = 0.154 \) and \( i = 2 \) (as \( \text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^- \), each mole of NaCl produces two moles of particles). Hence:

\[
\Pi = (2 \times 0.154 \text{ mol L}^{-1}) \times (0.08206 \text{ atm L K}^{-1} \text{ mol}^{-1}) \times ((37 + 273) \text{ K})
\]

\[
= 7.84 \text{ atm}
\]

Answer: 7.84 atm

Why is it better to use a saline solution rather than pure water when administering drugs intravenously?

Saline solution is isotonic with blood plasma. Injection water would have a hypotonic effect and cause lysis of cells.
Calculate the osmotic pressure of a solution of 1.0 g of glucose (C₆H₁₂O₆) in 1500 mL of water at 37 °C.

The osmotic pressure $\Pi = cRT$ where $c$ is the concentration.

The molar mass of glucose is:

$$(6 \times 12.01 \text{ (C)}) + (12 \times 1.008 \text{ (H)}) + (6 \times 16.00 \text{ (O)}) \text{ g mol}^{-1} = 180.156 \text{ g mol}^{-1}$$

$1.0 \text{ g of glucose corresponds to } \frac{\text{mass}}{\text{molar mass}} = \frac{1.0 \text{ g}}{180.156 \text{ g mol}^{-1}} = 0.0056 \text{ mol}$

The concentration when this amount is dissolved in 1500 mL = 1.5 L is:

$$c = \frac{\text{number of moles}}{\text{volume}} = \frac{0.0056 \text{ mol}}{1.5 \text{ L}} = 0.0037 \text{ M}$$

Hence,

$$\Pi = cRT = (0.0037 \text{ mol L}^{-1}) \times (0.08206 \text{ atm L K}^{-1} \text{ mol}^{-1}) \times ((273 + 37) \text{ K})$$

$$= 0.094 \text{ atm}.$$  

Answer: \text{0.094 atm}

Explain why a drip for intravenous administration of fluids is made of a solution of NaCl at a particular concentration rather than pure water.

Blood plasma is isotonic with cells (same osmotic pressure). Using saline drip of same osmotic pressure as blood prevents haemolysis or crenation of red blood cells.
Explain, in terms of chemical bonding and intermolecular forces, the following trend in melting points: \( \text{CH}_4 < \text{I}_2 < \text{NaCl} < \text{silica (SiO}_2\text{)} \)

There are only dispersion forces between the molecules in \( \text{CH}_4 \) and \( \text{I}_2 \). The I atom is a large, many-electron atom so its electron cloud is more easily polarised than the C or H in \( \text{CH}_4 \) and therefore \( \text{I}_2 \) has stronger dispersion forces and the higher melting point. \( \text{NaCl} \) is an ionic compound with strong coulombic attraction between the \( \text{Na}^+ \) ions and the \( \text{Cl}^- \) ions packed together in the solid. Silica is a covalent network solid. Melting it requires breaking of the very strong covalent Si–O bonds, so it has the highest melting point.
• Draw a Lewis structure and thus determine the geometry of the $\text{ICl}_4^-$ ion. (The I is the central atom.)

There are two lone pairs and 4 bonds around the iodine: the geometry is based on an octahedron with the lone pairs located opposite to one another to minimise repulsion between them. The geometry of the actual molecule is therefore square planar.

• Explain briefly, in terms of intermolecular forces, why an analogue of DNA could not be made with phosphorus atoms replacing some nitrogen atoms, while still retaining a double-helical structure.

The double helical structure is held together by hydrogen bonding between the cytosine and guanine ($\text{C}\equiv\text{G}$) and the adenine and thymine ($\text{A}=\text{T}$) base pairs.

No H-bonding would occur if the electronegative N atoms in these bases were replaced with P atoms.

• The solubility of nitrogen in water at 25 °C and 1.0 atm is 0.018 g L$^{-1}$. What is its solubility at 0.50 atm and 25 °C?

Henry’s law states that the concentration of a gas in a liquid is directly proportional to the partial pressure of the gas above the solution:

$$c_{\text{gas}} = k_H p_{\text{gas}} \quad \text{(at constant } T)$$

where $k_H$ is Henry’s law constant for the gas.

Halving the pressure whilst keeping the temperature constant will therefore half the solubility. The solubility is thus halved to $\frac{1}{2} \times 0.018 \text{ g L}^{-1} = 0.009 \text{ g L}^{-1}$

Answer: 0.009 g L$^{-1}$