1. A solution prepared by dissolving 0.30 g of polyacrylamide in 100 mL of water has an osmotic pressure of 8.3 x 10^{-5} atm at 25 °C. What molar concentration of glucose would be isotonic with this solution?

Isotonic means identical osmotic pressure.

\[ \pi = cRT \]

so \[ 8.3 \times 10^{-5} \text{ atm} = c(0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1})(298 \text{ K}) \]

\[ c = 3.4 \times 10^{-6} \text{ mol L}^{-1} \]

2. Rank the following solutions in order of increasing osmotic pressure:

ranking: glucose < NaCl < CaCl₂ < HCl < H₂SO₄

Total conc: 0.5 M < 1.0 M < 1.5 M < 2 M < ~3 M

3. A solution is prepared by dissolving 1.00 mg of an unknown protein in 1.00 mL of water. The osmotic pressure of the solution was measured to be 95 Pa at 25 °C. What is the molecular weight of the protein?

\[ \pi = cRT \]

(95x10^{-3} kPa / 101.3 kPa atm⁻¹) = c(0.08206 L atm K⁻¹ mol⁻¹)(298 K)

\[ c = 3.8 \times 10^{-5} \text{ mol L}^{-1} \]

Amount in 1 mL is 3.8 x 10⁻⁸ mol

This has a mass of 1 mg = 1 x 10⁻³ g

∴ Molecular weight is 1 x 10⁻³ g / 3.8 x 10⁻⁸ mol = 2.6 x 10⁴ g mol⁻¹

4. The ionic product of water, \( K_w \) varies with temperature and has a value of approximately 2.49 x 10⁻¹⁴ M² at 37 °C. What is the pH of neutral water at blood temperature (37 °C)?

\[ K_w = [H^+][OH^-] \]

at 37 °C \([H^+] = \sqrt{2.49} \times 10^{-14} \text{ M}^2 = 1.57 \times 10^{-7} \text{ M} \]

\[ \text{pH} = -\log[H^+] \]

at 37 °C pH = 6.80

5. Sea water from the Gulf of Mexico contains approximately 59 parts salt per 1000. Given the cryoscopic constant of water is 1.86 K mol⁻¹ kg, at what temperature would the water of the Gulf freeze?

59 g of NaCl / kg of water

Rel Molar Mass of NaCl = 58.45

No of moles of NaCl = 59 / 58.45 = 1.01

No of moles of particles (Na⁺ + Cl⁻) = 2.02

\[ \Delta T = (1.86 \text{ K mol}^{-1} \text{ kg}) \times (2.02 \text{ mol kg}^{-1}) = 3.76 \text{ K} \]

The Gulf would freeze at – 3.8°C (269.2 K)
6. What is the pH of the resulting solutions from the following reactions?

a) Dissolving 10 g of NaOH in water and making the solution up to 500 mL

\[ [\text{OH}^-] = \frac{(10 \, \text{g}/40 \, \text{gmol}^{-1})}{0.500 \, \text{L}} = 0.50 \, \text{M} \]
\[ \therefore \text{pOH} = 0.30, \]
\[ \text{and pH} = 13.70 \]

b) Diluting 20 mL of 10 M nitric acid to 1.0 L

\[ [\text{HNO}_3] \text{ after dilution} = \frac{(20/1000) \, 10 \, \text{M}}{10 = 0.20 \, \text{M} \]
\[ \text{pH} = 0.70 \]

c) Mixing 30 mL of 2.0 M H\text{SO}_4 with 70 mL of 1.0 M KOH

amount H\text{+} in 30 mL of 2 M H\text{SO}_4 = 0.12 \, \text{mol} \\
amount OH\text{+} in 70 mL of 1 M KOH = 0.07 \, \text{mol} \\
excess H\text{+} in 100 mL solution, [H\text{+}] = 0.05\text{mol} / 0.1L = 0.50 \, \text{M} \\
\[ \therefore \text{pH} = 0.30 \]

d) Dissolving 5.0 L of HCl (g) at 99 kPa and 20 °C in 1.0 L of water

\[ \text{PV} = nRT \]
\[ n = \frac{(99 \, \text{kPa}/101.3 \, \text{kPa atm}^{-1})(5 \, \text{L})}{(0.08206 \, \text{L atm K}^{-1} \, \text{mol}^{-1})(293 \, \text{K})} \]
\[ = 0.20 \, \text{mol} \]
\[ [\text{H\text{+}}] = 0.20 \, \text{M} \]
\[ \text{and pH} = 0.70 \]

7. Lactic acid (C\textsubscript{3}H\textsubscript{6}O\textsubscript{3}), a monoprotic acid, is a waste product that accumulates in muscle tissue during exertion, leading to pain ("cramp") and a feeling of fatigue. In a 0.100 M aqueous solution, lactic acid is 3.7\% dissociated.

If the equilibrium concentration of H\text{+} ion is \( x \) mol L\textsuperscript{-1} write the equilibrium expression for \( K_a \) in terms of \( x \) and thus work out the equilibrium concentrations, the value of pH and calculate \( K_a \) for lactic acid.

\[ K_a = [\text{H\text{+}}][\text{A}^-]/[\text{HA}] = x^2/(0.100 - x) \]

if 3.7\% dissociates, then \[ [\text{H\text{+}}] = [\text{A}^-] = 3.7\% \times 0.100 \, \text{M} = 3.7 \times 10^{-3} \, \text{M} \]
and \[ [\text{HA}] = 0.100 - 3.7 \times 10^{-3} \, \text{M} = 0.0963 \, \text{M} \]
\[ \therefore \text{pH} = 2.43 \]
\[ K_a = (3.7 \times 10^{-3} \, \text{M})^2 / 0.0963 \, \text{M} = 1.4 \times 10^{-4} \, \text{M} \]
or \( pK_a = 3.85 \)