Calculations of Tonicity (p. 206)-- chapter 11

1. Isotonic sodium chloride solution contains 0.9% w/v sodium chloride. If the E-value of boric acid is 0.52, calculate the percentage strength (w/v) of an isotonic solution of boric acid.

0.9% w/v sodium chloride = 0.9 g / 100 mL sodium chloride

0.9 g / 0.52 = 1.73 g boric acid ---> NaCl / E value = boric acid

1.73 g / 100 mL = 1.73% w/v

2. Sodium chloride is a 2-ion electrolyte, dissociating 90% in a certain concentration. Calculate (a) its dissociation factor and (b) the freezing point of a molal solution.

(a) On the basis of 90% dissociation, 100 particles of sodium chloride will yield:

- 90 zinc ions
- 90 sulfate ions
- 10 undissociated particles or
- 190 particles

Because 190 particles represent 1.9 times as many particles as were present before dissociation, the dissociation (i) factor is 1.9.

190/100 = 1.9

(b) ΔT=i*k*f*m

Where k{f} is a constant given as 1.86 for freezing point depression.

i is dissociation factor( calculated above)

ΔT=1.9*1.86*1=3.534

So, freezing point is -3.534°C

3. A solution of anhydrous dextrose (m.w. 180) contains 25 g in 500 mL of water. Calculate the freezing point of the solution.
Freezing point = \( kf \times m \)

\( M = \text{molal} \); molal is amount of moles/1 kg of solvent or amount of moles/1 L solvent = 25 g / 180 g/mol = 0.1389 moles

\( (0.1389 \text{ moles} / 500 \text{ mL}) \times 2 = 0.2778 \text{ m} \)

\( K = -1.86 \)

Freezing point = \(-1.86 \times 0.2778 \text{ m}\) = -0.52 degrees Celsius

4. Procaine hydrochloride (m.w. 273) is a 2-ion electrolyte, dissociating 80% in a certain concentration.

Molec weight of Procaine hydrochloride = 273 g/mol

\( n \) # of ions = 2

Dissociating frac = 80/100 = 0.8

(a) Calculate its dissociation factor.

Dissociation factor is \( i \)

\( i = 1 + \text{dissociation frac} \times (n-1) \)

\( i = 1 + 0.8(2-1) \)

\( i = 1 + 0.8 \)

\( i = 1.8 \)

(b) Calculate its sodium chloride equivalent.

\( E \text{ value} = \text{MW of NaCl} \times \text{NaCl} \times i \text{ of substance} \times \text{MW of substance} \)

\( E \text{ value} = 58.5 \times 1.8 \times 1.8 \times 273 \)

\( E \text{ value} = 0.21 \)

(c) Calculate the freezing point of a molal solution of procaine hydrochloride.
\[ \Delta T = i \cdot k_f \cdot m \]

Where \( k_f \) is a constant given as 1.86 for freezing point depression.

\[ \Delta T = 1.8 \cdot 1.86 \cdot 1 \]

\[ \Delta T = 3.348 \]

Freezing point = -3.348 degrees celsius

\[ \Delta T = 0 \text{ degrees celsius} - T \]

3.348 = -T

T = -3.348 degrees celsius

5. The freezing point of a molal solution of a nonelectrolyte is -1.86°C. What is the freezing point of a 0.1% solution of zinc chloride (m.w. 136), dissociating 80%? (For lack of more definite information, assume that the volume of the molal solution is approximately 1 liter.)

Kf is -1.86

\( m = \text{molality} \)

\[ 0.1 \text{ g} / 100 \text{ mL} \cdot (10) = 1 \text{ g}; \ 1\text{g}/136\text{g/mol} = 0.00735 \text{ moles} \]

\( i = \text{dissociation factor}; \ i = 1 + \text{dissociation frac} \cdot (n-1) \)

\[ i = 1 + 0.8 \cdot (3-1) \]

\[ i = 2.6 \]

Change in temp = 2.6 \cdot -1.86 \cdot 0.00735 = -0.036 \text{ degrees celsius} \]

6. How many milligrams of sodium chloride should be used in compounding the prescription?

The solution contains 0.3 g ephedrine sulfate, which has a sodium chloride equivalent (E value) of 0.23.
The amount of sodium chloride that has the same osmotic pressure as 0.3 g of ephedrine sulfate is:

\[0.3 \text{ g} \times 0.23 = 0.069 \text{ g}\]

\[0.3 \text{ g} \times 0.2 = 0.06 \text{ g}\]

\[
\frac{0.9 \text{ g NaCl}}{100 \text{ mL}} = \frac{x}{30 \text{ mL}}
\]

100x = 27

X = 0.27 g NaCl

0.27 g NaCl - 0.069 g = 0.201 g NaCl

0.27 g NaCl - 0.06 g = 0.210 g NaCl

The ephedrine sulfate in the solution exerts an osmotic pressure equal to that of 0.069 g of NaCl. Therefore, to find the amount of sodium chloride to add, it is necessary to subtract 0.069 g from the amount of NaCl that would have been needed had the salt been the only solute in the system.

0.27 g - 0.069 g = 0.201 g = 201 mg

To prepare the solution, dissolve 300 mg of ephedrine sulfate and 201 mg of sodium chloride in sufficient water to make a total volume of 30 mL.

7. How much sodium chloride should be used in compounding the prescription?
Benoxinate hydrochloride E value: 0.17

Fluorescein sodium E value: 0.31

Benoxinate hydrochloride-- 0.4 g / 100 mL; \( \frac{0.4 \text{ g}}{100 \text{ mL}} \times \frac{x}{30 \text{ mL}} = 0.12 \times 0.17 = 0.0204 \)

Fluorescein sodium-- 0.25 g / 100 mL; \( \frac{0.25 \text{ g}}{100 \text{ mL}} \times \frac{x}{30 \text{ mL}} = 0.075 \times 0.31 = 0.02325 \)

0.0204 + 0.02325 = 0.04365 g

0.27 g - 0.04365 g = 0.22635 g or 226.35 mg of NaCl

8. How much boric acid should be used in compounding the prescription?

![Zinc sulfate prescription](image)

Zinc sulfate → E value = 0.15

Boric acid → E value = 0.52

E value of ZnSO4

1 g of zinc sulfate = 0.15 g of NaCl

So 0.06 g of ZnSO4 → ? g of NaCl

\[
\frac{1 \text{ g Zinc sulfate}}{0.15 \text{ g NaCl}} = \frac{0.06 \text{ g of Zinc sulfate}}{x \text{ g of NaCl}}
\]

\[X = \frac{0.15 \times 0.06}{1 \text{ g of NaCl}}\]
X = 0.009 g of NaCl

We know that isotonic solution = 0.9% w/v NaCl

\[
\% \text{ w/v} = \frac{\text{mass of NaCl}}{\text{volume of solution}} \times 100\%
\]

\[
0.9\% = \frac{\text{mass of NaCl}}{30 \text{ mL}} \times 100\%
\]

Mass of NaCl needed to make 30 mL isotonic = 0.27 g

Amount of NaCl needed to be added to the solution = 0.27g - 0.009g = 0.261g

E value of Boric acid = 0.52

1 g of boric acid = 0.52 g of NaCl

So ? g of boric acid = 0.261 g of NaCl

Amount of Boric acid needed = \[
\frac{4 \text{ g of boric acid}}{0.52 \text{ g of NaCl}} = \frac{x \text{ g of boric acid}}{0.261 \text{ g of NaCl}}
\]

X = 0.502 g of Boric Acid should be used in the prescription!!!

9. How many milliliters of the buffer solution (E = 0.30) should be used to render the solution isotonic? (For lack of more definite information, assume that the specific gravity of the buffer solution is 1.)

Step 1: How much NaCl do you need?
\[ \frac{0.9 \, g}{100 \, mL} \times 10 \, mL = 0.09 \, g \, NaCl \]

Step 1: How much cromolyn sodium, in terms of NaCl, is present in solution?

Cromolyn sodium 4% (w/v) = \[ \frac{4 \, g}{100 \, mL} \]

\[ \frac{4 \, g}{100 \, mL} = \frac{x \, g}{10 \, mL} \]

100x = 40

x = 0.40 g cromolyn sodium

0.40 g \times 0.14 = 0.056 g NaCl to represent cromolyn sodium

Step 2: How much benzalkonium chloride, in terms of NaCl, is present in solution?

Benzalkonium chloride 1:10,000 (w/v) = \[ \frac{1 \, g}{10,000 \, mL} \]

\[ \frac{1 \, g}{10,000 \, mL} = \frac{x \, g}{10 \, mL} \]

10 = 10,000x

0.001 g = x

0.001 g \times 0.16 = 0.00016 g NaCl to represent benzalkonium chloride

Step 3: How much buffer solution do you need?

0.09 g NaCl - (0.056 g NaCl + 0.00016 g NaCl) = 0.03384 g NaCl

0.03384 g NaCl / 0.30 = 0.113 mL buffer solution

10. How many grams of sodium chloride should be used in preparing the solution?

Dextrose, anhydrous
Sodium chloride
Sterile water for injection ad
Label: Isotonic dextrose and saline solution
Dextrose anhydrous 2.5%

→ 2.5g per 100mL

→ 1000mL contains 2.5 \times \frac{1000}{100} = 25g

We also know that isotonic solution = 0.9% w/v NaCl → 0.9g/100mL

So ….

25 g \times 0.18 = 4.5 g of NaCl represented by dextrose anhydrous

0.18 is the E value of dextrose anhydrous

1000 \times 0.0009 = 9g NaCl in 1000mL of isotonic solution

9 - 4.5 = 4.5 g of NaCl required to make the solution isotonic

11. A sterile ophthalmic preparation contains 0.6% besifloxacin (E = 0.08) in a 5-mL container. Calculate the quantity of sodium chloride required for isotonicity.

\[
\frac{0.6 \ g}{100 \ mL} = \frac{\ x \ g}{5 \ mL}
\]

100x = 3

X = 0.03 g besifloxacin

0.03 g \times 0.08 = 0.0024 g NaCl represented by besifloxacin

5 \times 0.009 = 0.045g NaCl in 5 mL of isotonic solution

0.045 g NaCl - 0.0024 g NaCl = 0.0426 g of NaCl = 42.6 mg NaCl required to make the solution isotonic

12. Calculate the effective quantity (g) of sodium chloride related to tonicity in 100 mL of an intravenous fluid labeled “5% dextrose in 0.45% sodium chloride,” and indicate whether the solution is isotonic, hypotonic, or hypertonic.

To calculate the effective quantity (g)

Let, intracellular fluid contain ⅔ rds of the total fluid and extracellular fluid contain ⅓ rd of the total cellular fluid.
0.45% NaCl is labelled

Total fraction = \(\frac{\frac{2}{3}}{1} + \frac{\frac{1}{3}}{3} = \frac{3}{3} \rightarrow 1\)

0.45% NaCl contains 0.45g of NaCl in 100mL

Therefore, the effective quantity of NaCl related to the tonicity of 5% dextrose & 0.45% NaCl = 0.45 x 3 → = 1.35g

Normal salinity = 0.9g, 0.45g is less than the normal salinity so the solution is hypotonic

13. How many milligrams of sodium chloride should be used in compounding the prescription?

![Rx sheet with ingredients and calculations]

14. How much boric acid should be used in compounding the prescription?

![Rx sheet with ingredients and calculations]

Step 1: How much NaCl is required to make 30 mL isotonic?

\[
\frac{0.9 \text{ g}}{100 \text{ mL}} \times 30 \text{ mL} = 0.27 \text{ g NaCl}
\]

Step 2: How much tetracaine hydrochloride, in terms of NaCl, is present in the solution?
If 1 g tetracaine hydrochloride = 0.18 g NaCl,

\[
\frac{1 \text{ g tetracaine hydrochloride}}{0.18 \text{ g NaCl}} = \frac{0.1 \text{ g tetracaine hydrochloride}}{x \text{ g NaCl}}
\]

X = 0.018 g NaCl

Step 3: How much zinc sulfate, in terms of NaCl, is present in the solution?

If 1 g zinc sulfate = 0.15 g NaCl

\[
\frac{1 \text{ g zinc sulfate}}{0.15 \text{ g NaCl}} = \frac{0.05 \text{ g zinc sulfate}}{x \text{ g NaCl}}
\]

X = 0.0075 g NaCl

Step 4: How much NaCl overall?

0.27 g NaCl - (0.018 g NaCl + 0.0075 g NaCl) = 0.2445 g NaCl

Step 5: How much boric acid overall?

\[
\frac{0.2445 \text{ g}}{0.52} = 0.47019 \text{ g boric acid} = 470.19 \text{ mg boric acid}
\]

15. How many milligrams of boric acid should be used in compounding the prescription?

Sol. homatropine hydrobromide 1% 15 mL
Make isoton. sol. with boric acid
Sig. for the eye

Step 1: How much NaCl is required to make 15 mL isotonic?

\[
\frac{0.9 \text{ g}}{100 \text{ mL}} \times 15 \text{ mL} = 0.135 \text{ g NaCl}
\]