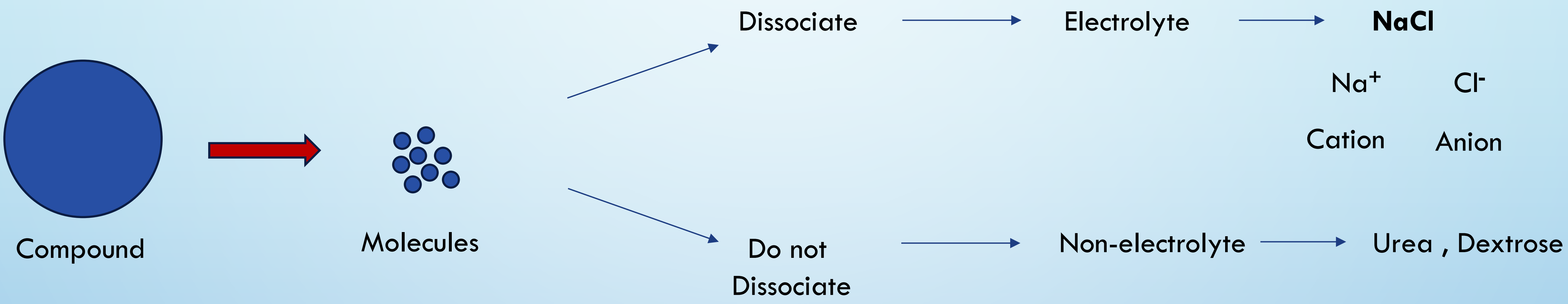
Chapter 12

# Electrolyte Solutions: Milliequivalents, Millimoles, And Milliosmoles

Assist. Lec. Ahmad Abdullah

Msc. Pharmaceutics

# Introduction




The molecules of chemical compounds in solution may remain intact, or they may dissociate into particles known as ions, which carry an electric charge.

# Introduction

- If electrodes carrying a weak current are placed in the solution, the ions move in a direction opposite to the charges.
- $Na^+$ ions move to the negative electrode (cathode) and are called cations.
- $Cl^-$ ions move to the positive electrode (anode) and are called anions.

# Introduction

- Electrolyte ions in the blood plasma include the cations $Na^+$, $K^+$, $Ca^{++}$, and $Mg^{++}$ and the anions $Cl^-$, $HCO_3^-$ , $HPO_4^-$ , $SO_4^-$ , organic acids$^-$, and protein$^-$.

- **Electrolytes** in body fluids play an important role in maintaining the acid-base balance in the body.
- They play a part in controlling body water volumes and help to regulate body metabolism.

# Applicable Dosage Forms

- ***Electrolyte preparations*** are used in the treatment of disturbances of the electrolyte and fluid balance in the body.

- In clinical practice, they are provided in the form of oral solutions and syrups, as dry granules intended to be dissolved in water or juice to make an oral solution, as oral tablets and capsules, and, when necessary, as intravenous infusions.


# Milliequivalents

- A chemical unit, the **milliequivalent (mEq)**, is now used almost exclusively in the US by clinicians, physicians, pharmacists, and manufacturers to express the concentration of electrolytes in solution.
- This unit **(mEq)**, of measure, is related to the total number of ionic charges in solution, and it takes note of the valence of the ions. In other words, it is a unit of measurement of the amount of chemical activity of an electrolyte.
- In the International System (SI), which is used in European countries and in many others throughout the world, molar concentrations [as millimoles per liter **(mmol/L)** and micromoles per liter **(µmol/L)**] are used to express most clinical laboratory values, including those of electrolytes.

- Under normal conditions, blood plasma contains 154 mEq of cations and an equal number of anions.
- However, it should be understood that normal laboratory values of electrolytes vary, albeit within a rather narrow range.
- The total concentration of **cations** always equals the total concentration of **anions**.
- Any number of milliequivalents of $Na^+$, $K^+$, or any $cation^+$ always reacts with precisely the same number of milliequivalents of $Cl^-$, $HCO_3^-$, or any $anion^-$.

- *For a given chemical compound, the milliequivalents of cation equals the milliequivalents of anion equals the milliequivalents of the chemical compound.*

## TABLE 12.1 BLOOD PLASMA ELECTROLYTES IN MILLIEQUIVALENTS PER LITER (mEq/L)

| CATIONS | mEq/L | ANIONS | mEq/L |
|---|---|---|---|
| $Na^+$ | 142 | $HCO_3^-$ | 24 |
| $K^+$ | 5 | $Cl^-$ | 105 |
| $Ca^{++}$ | 5 | $HPO_4^{--}$ | 2 |
| $Mg^{++}$ | 2 | $SO_4^{--}$ | 1 |
| | | Org. Ac.$^-$ | 6 |
| | | Proteinate$^-$ | 16 |
| | 154 | | 154 |

- The interesting point is that if we dissolve enough potassium chloride in water to give us 40 mEq of $K^+$ per liter, we also have exactly 40 mEq of $Cl^-$, but the solution will not contain the same weight of each ion.

- The concentration of electrolytes in intravenous infusion fluids is most often stated in mEq/L.

- Equivalent weight = M.wt/valence
- To convert milligrams (mg) to milliequivalents (mEq):

$$mEq = \frac{mg \times Valence}{\text{Atomic, formular, or molecular weight}}$$

- To convert milliequivalents (mEq) to milligrams (mg):

$$mg = \frac{mEq \times \text{Atomic, formula, or molecular weight}}{Valence}$$

- To convert milliequivalents per milliliter (mEq/ml) to milligrams per milliliter (mg/ml):

$$mg/mL = \frac{mEq/mL \times \text{Atomic, formula, or molecular weight}}{Valence}$$

## TABLE 12.3 VALUES FOR SOME IMPORTANT IONS

| ION | FORMULA | VALENCE | ATOMIC OR FORMULA WEIGHT | EQUIVALENT WEIGHT[a] |
|---|---|---|---|---|
| Aluminum | $Al^{+++}$ | 3 | 27 | 9 |
| Ammonium | $NH_4^+$ | 1 | 18 | 18 |
| Calcium | $Ca^{++}$ | 2 | 40 | 20 |
| Ferric | $Fe^{+++}$ | 3 | 56 | 18.7 |
| Ferrous | $Fe^{++}$ | 2 | 56 | 28 |
| Lithium | $Li^+$ | 1 | 7 | 7 |
| Magnesium | $Mg^{++}$ | 2 | 24 | 12 |
| Potassium | $K^+$ | 1 | 39 | 39 |
| Sodium | $Na^+$ | 1 | 23 | 23 |
| Acetate | $C_2H_3O_2^-$ | 1 | 59 | 59 |
| Bicarbonate | $HCO_3^-$ | 1 | 61 | 61 |
| Carbonate | $CO_3^{--}$ | 2 | 60 | 30 |
| Chloride | $Cl^-$ | 1 | 35.5 | 35.5 |
| Citrate | $C_6H_5O_7^{---}$ | 3 | 189 | 63 |
| Gluconate | $C_6H_{11}O_7^-$ | 1 | 195 | 195 |
| Lactate | $C_3H_5O_3^-$ | 1 | 89 | 89 |
| Phosphate | $H_2PO_4^-$ | 1 | 97 | 97 |
| | $HPO_4^{--}$ | 2 | 96 | 48 |
| Sulfate | $SO_4^{--}$ | 2 | 96 | 48 |

[a] Equivalent weight $= \dfrac{\textit{Atomic or formula weight}}{\textit{Valence}}$

*What is the concentration, in milligrams per milliliter, of a solution containing 2 mEq of potassium chloride (KCl) per milliliter?* $K^+ = 39$ , $Cl^- = 35.5$

$$\text{Molecular weight of KCl} = 74.5$$

$$\text{Equivalent weight of KCl} = 74.5$$

$$1 \text{ mEq of KCl} = \frac{1}{1000} \times 74.5 \text{ g} = 0.0745 \text{ g} = 74.5 \text{ mg}$$

$$2 \text{ mEq of KCl} = 74.5 \text{ mg} \times 2 = 149 \text{ mg/mL, } \textit{answer.}$$

Or, by using the preceding equation: $mg/mL = \frac{mEq/mL \times \text{Atomic, formula, or molecular weight}}{\text{Valence}}$

$$mg/mL = \frac{2\ (mEq/mL) \times 74.5}{1}$$

$$= 149 \text{ mg/mL, } \textit{answer.}$$

*What is the concentration, in grams per milliliter, of a solution containing 4 mEq of calcium chloride ($CaCl_2 \cdot 2H_2O$) per milliliter?* (Ca=40, Cl=35.5, H=1, O=16)

Recall that the equivalent weight of a binary compound may be found by dividing the formula weight by the *total valence* of the positive or negative radical.

$$\text{Formula weight of } CaCl_2 \cdot 2H_2O = 147$$
$$\text{Equivalent weight of } CaCl_2 \cdot 2H_2O = {}^{147}\!/_{2} = 73.5$$
$$1 \text{ mEq of } CaCl_2 \cdot 2H_2O = {}^{1}\!/_{1000} \times 73.5 \text{ g} = 0.0735 \text{ g}$$
$$4 \text{ mEq of } CaCl_2 \cdot 2H_2O = 0.0735 \text{ g} \times 4 = 0.294 \text{ g/mL, } \textit{answer.}$$

Or, solving by dimensional analysis:

$$mg/mL = \frac{mEq/mL \times \text{Atomic, formula, or molecular weight}}{\text{Valence}}$$

$$\frac{1 \text{ g } CaCl_2 \cdot 2H_2O}{1000 \text{ mg } CaCl_2 \cdot 2H_2O} \times \frac{147 \text{ mg}}{1 \text{ mmole}} \times \frac{1 \text{ mmole}}{2 \text{ mEq}} \times \frac{4 \text{ mEq}}{1 \text{ mL}} = 0.294 \text{ g/mL, } \textit{answer.}$$

★ *Note:* The water of hydration molecules does not interfere in the calculations as long as the correct molecular weight is used.

*What is the percent (w/v) concentration of a solution containing 100 mEq of ammonium chloride per liter?*

$$\text{Molecular weight of } NH_4Cl = 53.5$$
$$\text{Equivalent weight of } NH_4Cl = 53.5$$
$$1 \text{ mEq of } NH_4Cl = \tfrac{1}{1000} \times 53.5 = 0.0535 \text{ g}$$
$$100 \text{ mEq of } NH_4Cl = 0.0535 \text{ g} \times 100 = 5.35 \text{ g/L or}$$
0.535 g per 100 mL, or 0.535%, *answer.*

**1 mEq** = M.wt/Valence =53.5mg/1 = 53.5 mg

Percent = in 100mL

100 mEq in 1000 mL

X mEq in 100 mL x=10 mEq

1 mEq 53.5 mg

10 mEq x mg

X= 535mg =0.535 g / 100mL. =0.535 % , answer.

*A solution contains 10 mg/100 mL of $K^+$ ions. Express this concentration in terms of milliequivalents per liter.*

Atomic weight of $K^+$ = 39

$$\text{mEq/mL} = \frac{mg/mL * Vlence}{\text{Atomic, formula, or molecular weight}}$$

$$\text{mEq}/L = \frac{mg/L * Vlence}{\text{Atomic, formula, or molecular weight}}$$

**10mg/ 100mL= 100mg/L**

Or, by the equation detailed previously:

$$\text{mEq/L} = \frac{100\ (\text{mg/L}) \times 1}{39}$$

$$= 2.56\ \text{mEq/L}, \textit{answer}.$$

*How many milliequivalents of potassium chloride are represented in a 15-mL dose of a 10% (w/v) potassium chloride elixir?*

$$\text{Molecular weight of KCl} = 74.5$$

$$\text{Equivalent weight of KCl} = 74.5$$

$$1 \text{ mEq of KCl} = \tfrac{1}{1000} \times 74.5 \text{ g} = 0.0745 \text{ g} = 74.5 \text{ mg}$$

$$\text{15-mL dose of 10\% (w/v) elixir} = 1.5 \text{ g or } 1500 \text{ mg of KCl}$$

$$mEq = \frac{mg \times Valence}{\text{Atomic, formular, or molecular weight}}$$

$$x = 20.1 \text{ mEq}, \textit{ answer.}$$

*How many milliequivalents of $Na^+$ would be contained in a 30-mL dose of the following solution?*

| | |
|---|---|
| Disodium hydrogen phosphate | 18 g |
| Sodium biphosphate | 48 g |
| Purified water ad | 100 mL |

Each salt is considered separately in solving the problem.

Disodium hydrogen phosphate

$$\text{Formula} = Na_2HPO_4.7H_2O$$

$$\text{Molecular weight} = 268 \text{ and the equivalent weight} = 134$$

$$\frac{18\ (g)}{x\ (g)} = \frac{100\ (mL)}{30\ (mL)}$$

$$x = 5.4 \text{ g of disodium hydrogen phosphate per 30 mL}$$

Sodium biphosphate

$$\text{Formula} = NaH_2PO_4.H_2O$$

$$\text{Molecular weight} = 138 \text{ and the equivalent weight} = 138$$

$$\frac{48\ (g)}{x\ (g)} = \frac{100\ (mL)}{30\ (mL)}$$

$$x = 14.4 \text{ g of sodium biphosphate per 30 mL}$$

$$mEq = \frac{mg \times Valence}{\text{Atomic, formular, or molecular weight}}$$

# THANK YOU

**Electrolyte Solutions**