Chapter 12

Electrolyte Solutions: Milliequivalents, Millimoles, And Milliosmoles

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MILLIMOLES AND MICROMOLES

- A **mole** is the molecular weight of a substance in grams.

- A **millimole** is one-thousandth of a mole.
- And a **micromole** is one-millionth of a mole.
- SI electrolyte conc. In mmol/L

Keep in Mind

- **Mole –** Mwt of a substance in grams
- **Millimole –** Mwt of substance in mg
- **Micromle –** Mwt of a substance in mcg

- **Monovalent species**
- mEq = mmol
- Eq.wt of a substance = Mwt/valence
- Mole of a substance = Mwt

Keep in Mind

To calculate millimoles (mmol):

A *millimole* is $^{1}/_{1000}$ of the gram molecular weight of a substance.

$$1 \text{ millimole} = \frac{\text{Molecular weight, grams}}{1000}$$

How many millimoles of monobasic sodium phosphate (m.w. 138) are present in 100 g of the substance?

$$\text{m.w.} = 138$$
$$1 \text{ mole} = 138 \text{ g}$$
$$\frac{1 \text{ (mole)}}{x \text{ (mole)}} = \frac{138 \text{ (g)}}{100 \text{ (g)}}$$
$$x = 0.725 \text{ moles} = 725 \text{ mmol, } \textit{answer.}$$

How many milligrams would 1 mmol of monobasic sodium phosphate weigh?

$$1 \text{ mole} = 138 \text{ g}$$
$$1 \text{ mmol} = 0.138 \text{ g} = 138 \text{ mg, } \textit{answer.}$$

Convert blood plasma levels of 0.5 μg/mL and 2μg/mL of tobramycin (mw = 467.52) to μmol/L.[1]

By dimensional analysis:

1 mole = 467.52 g

1 $\mathcal{M}$mol = 467.52 $\mathcal{M}$g

$$\frac{0.5\ \mu g}{1\ mL} \times \frac{1\ \mu mol}{467.52\ \mu g} \times \frac{1000\ mL}{1\ L} = 1.07\ \mu mol/L$$

and,

$$\frac{2\ \mu g}{1\ mL} \times \frac{1\ \mu mol}{467.52\ \mu g} \times \frac{1000\ mL}{1\ L} = 4.28\ \mu mol/L, \textit{ answers.}$$

OSMOLARITY

- Osmotic pressure is important to biologic processes that involve the diffusion of solutes or the transfer of fluids through semipermeable membranes.
- Osmotic pressure is proportional to the total number of particles in solution.
- The unit used to measure osmotic concentration is the milliosmole (mOsmol).

- For dextrose, a **nonelectrolyte**, 1 mmol (1 formula weight in milligrams) represents 1 mOsmol..
- This relationship is not the same with **electrolytes**, however, because the total number of particles in solution depends on the degree of dissociation of the substance in question.

- Assuming complete dissociation, 1 mmol of NaCl represents 2 mOsmol **(Na^+ + Cl^-)** of total particles.
- 1 mmol of $CaCl_2$ represents 3 mOsmol **(Ca^{2+} + 2 Cl^-)** of total particles.
- and 1 mmol of sodium citrate ($Na_3C_6H_5O_7$) represents 4 mOsmol ($3Na^+$ + $C_6H_5O_7^{\,-}$) of total particles.
- The milliosmolar value of separate ions of an electrolyte may be obtained by dividing the concentration, in milligrams per liter, of the ion by its atomic weight.
- The milliosmolar value of the whole electrolyte in solution is equal to the sum of the milliosmolar values of the separate ions,

$$\text{mOsmol/L} = \frac{\text{Weight of substance (g/L)}}{\text{Molecular weight (g)}} \times \text{Number of species} \times 1000$$

- A distinction also should be made between the terms **osmolarity** and **osmolality**. Whereas osmolarity is the milliosmoles of solute per liter of solution, osmolality is the milliosmoles of solute per kilogram of solvent.

- **Normal serum osmolality is considered to be within the range of 275 to 300 mOsmol/kg**

- Abnormal blood osmolality that deviates from the normal range can occur in association with shock, trauma, burns, water intoxication (overload), electrolyte imbalance, hyperglycemia, or renal failure.

Summary

Osmolarity

- Osmotic pressure is proportional to the total number of particles in a solution
- Measured in mOsmol
- Example
  - 1 mmol dextrose = 1 mOsmol total particles
  - 1 mmol NaCl = 2 mOsmol total particles
  - 1 mmol CaCl2 = 3 mOsmol total particles
  - 1 mmol Na3C6H5O7 = 4 mOsmol total particles

Millimoles and Milliosmoles

To calculate millimoles (mmol):

A *millimole* is $^{1}/_{1000}$ of the gram molecular weight of a substance.

$$1 \text{ millimole} = \frac{\text{Molecular weight, grams}}{1000}$$

To calculate milliosmoles (mOsmol):

A *milliosmole* is $^{1}/_{1000}$ of an osmol. When substances do not dissociate, the numbers of millimoles and milliosmoles are the same. There are 2 milliosmoles per millimole for substances that dissociate into two particles and 3 milliosmoles per millimole for substances that dissociate into three particles.

$$\text{mOsmol} = \text{mg of drug} \times \frac{1 \text{ mmol of drug}}{\text{Molecular weight (mg)}}$$

Example Calculations of Milliosmoles

A solution contains 5% of anhydrous dextrose in water for injection. How many milliosmoles per liter are represented by this concentration?

$$\text{Formula weight of anhydrous dextrose} = 180$$

$$1 \text{ mmol of anhydrous dextrose (180 mg)} = 1 \text{ mOsmol}$$

$$5\% \text{ solution contains } 50 \text{ g or } 50{,}000 \text{ mg/L}$$

$$50{,}000 \text{ mg} \div 180 = 278 \text{ mOsmol/L, } \textit{answer.}$$

Or, solving by dimensional analysis:

$$mOsmol = mg\ of\ drug \times \frac{1\ mmol\ of\ drug}{Molecular\ weight\ (mg)}$$

$$\frac{50{,}000 \text{ mg}}{1 \text{ L}} \times \frac{1 \text{ mOsmol}}{180 \text{ mg}} = 278 \text{ mOsmol/L, } \textit{answer.}$$

A solution contains 156 mg of K^+ ions per 100 mL. How many milliosmoles are represented in a liter of the solution?

$$\text{mOsmol/L} = \frac{\text{Weight of substance (g/L)}}{\text{Molecular weight (g)}} \times \text{Number of species} \times 1000$$

$$\text{mOsmol} = \text{mg of drug} \times \frac{\text{1 mmol of drug}}{\text{Molecular weight (mg)}}$$

$$\text{Atomic weight of } K^+ = 39$$
$$\text{1 mmol of } K^+ \text{ (39 mg)} = \text{1 mOsmol}$$
$$\text{156 mg of } K^+ \text{ per 100 mL} = \text{1560 mg of } K^+ \text{ per liter}$$
$$\text{1560 mg} \div 39 = \text{40 mOsmol, } \textit{answer.}$$

How many milliosmoles are represented in a liter of a 0.9% sodium chloride solution?

Osmotic concentration (in terms of milliosmoles) is a function of the total number of particles present. Assuming complete dissociation, 1 mmol of sodium chloride (NaCl) represents 2 mOsmol of total particles ($Na^+ + Cl^-$).

$$\text{Formula weight of NaCl} = 58.5$$
$$\text{1 mmol of NaCl (58.5 mg)} = \text{2 mOsmol}$$
$$1000 \times 0.009 = \text{9 g or 9000 mg of NaCl per liter}$$

$$\textit{mOsmol} = \text{9000 mg } X\ \frac{\textit{2 mmol of drug}}{\text{58.5 (mg)}} = 307.7\text{, or 308}$$

mOsmol

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

Maintaining body water and electrolyte balance is an essential component of good health. Water provides the environment in which cells live and is the primary medium for the ingestion of nutrients and the excretion of metabolic waste products.

Normally, the osmolality of body fluid is maintained within narrow limits through dietary input, the regulatory endocrine processes, and balanced output via the kidneys, lungs, skin, and the gastrointestinal system.

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

- In clinical practice, fluid and electrolyte therapy is undertaken either to provide maintenance requirements or to replace serious losses or deficits. Body losses of water and/or electrolytes can result from a number of causes, including vomiting, diarrhea, profuse sweating, fever, chronic renal failure, diuretic therapy, surgery, and others.
- The type of therapy undertaken (i.e., oral or parenteral) and the content of the fluid administered depend on a patient's specific requirements.

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

For example, a patient taking **diuretics** may simply require a daily oral **potassium supplement along with adequate intake of water**. An **athlete** may require **rehydration with or without added electrolytes**. **Hospitalized patients commonly receive parenteral maintenance therapy of fluids and electrolytes** to support ordinary metabolic function. In **severe cases of deficit, a patient may require the prompt and substantial intravenous replacement of fluids and electrolytes** to restore acute volume losses resulting from surgery, trauma, burns, or shock.

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

In general terms, **1500 mL of water per square meter of body surface area** may be used to calculate the daily requirement for adults.

$$\text{Plasma osmolality (mOsm/kg)} = 2\,([\text{Na}] + [\text{K}])\,\text{plasma} + \frac{[\text{BUN}]}{2.8} + \frac{[\text{Glucose}]}{18}$$

where: sodium (Na) and potassium (K) are in mEq/L, and blood urea nitrogen (BUN) and glucose concentrations are in mg/100 mL (mg/dL).

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

Example Calculations of Water Requirements and Electrolytes in Parenteral Fluids

Calculate the estimated daily water requirement for a healthy adult with a body surface area of 1.8 m^2.

$$\text{Water Requirement} = 1500\ \text{mL/m}^2$$

$$\frac{1\text{m}^2}{1.8\ \text{m}^2} = \frac{1500\ \text{mL}}{x\ \text{mL}}$$

$$x = 2700\ \text{mL, } \textit{answer.}$$

CLINICAL CONSIDERATIONS OF WATER AND ELECTROLYTE BALANCE

Estimate the plasma osmolality from the following data: sodium, 135 mEq/L; potassium, 4.5 mEq/L; blood urea nitrogen, 14 mg/dL; and glucose, 90 mg/dL.

Equation from text:

$$\text{mOsm/kg} = 2\,([\text{Na}] + [\text{K}]) + \frac{[\text{BUN}]}{2.8} + \frac{[\text{Glucose}]}{18}$$

$$\text{mOsm/kg} = 2\,(135\ \text{mEq/L} + 4.5\ \text{mEq/L}) + \frac{14\ \text{mg/dL}}{2.8} + \frac{90\ \text{mg/dL}}{18}$$

$$= 2\,(139.5) + 5 + 5$$

$$= 289, \textit{ answer.}$$

THANK YOU

Electrolyte Solutions