

Milliequivalents, Millimoles, and Milliosmoles

Electrolytes vs Nonelectrolytes

- Compounds in solution are often referred to as either electrolytes or nonelectrolytes
 - Electrolytes are compounds that in solution dissociate to varying degrees into “ions” which have an electrical charge
 - ◆ Examples: NaCl, KCl, MgSO₄
 - Nonelectrolytes are compounds which do not dissociate in solution
 - ◆ Examples: dextrose, urea

Cations versus Anions

- In solution ions move in a direction opposite their charge
- Cations: positively charged ions
 - When placed in a solution the ions move to the negative electrode (or the cathode)
 - Examples: Na^+ , K^+ , Ca^{++} , Mg^{++}
- Anions: negatively charged ions
 - When placed in solution the ions move towards the positive electrode (or the anode)
 - Examples: Cl^- , HCO_3^- , SO_4^- , HPO_4^-

Terminology

- Mole= Avogadro's number (6.023×10^{23}) of molecules
- Molecular Weight (MW)= weight in grams of one mole of compound
- Millimoles (mmole)= 1000 x moles
 - g/mole = mg/mmole
- Valence= amount of charge of an ion
- Equivalents (Eq)= number of univalent counter ions needed to react with each molecule of substance
 - HCl has 1 equivalent per mole in that one mole of H^+ reacts with one mole of Cl^-

Milliequivalent

- In the United States, the concentration of electrolytes in solution is expressed in terms of milliequivalents (mEq)
 - **EXCEPTION: Phosphorous is usually referred to in terms of mmoles**
 - Note: in Europe concentrations of electrolytes are often expressed in terms of millimoles per liter or micromoles per liter)
- Refers to the chemical activity of an electrolyte
- Is related to the total number of ionic charges in solution and considers the valence (charge) of each ion
- For a given chemical compound, the milliequivalents of cations equals that of anions
 - Example: a solution of NaCl will contain the same number of milliequivalents of Na⁺ (the cation) as it will Cl⁻ (the anion).
- There is a trend to shift from using mEq to using mg of the given ion. Beware that this can be confusing! They are not EQUIVALENT!!! And mg of a given ion is not equivalent to mg of the compound. (i.e., mEq CaCl₂ is not equal to mg CaCl₂ which is not equal to mg Ca ion.

Milliequivalents

- mEq = represents amount in milligrams, of a solute equal to 1/1000 of its gram equivalent weight taking into account the valence of the ions.

Equivalent weight = formula weight divided by the total valence

$$\text{mEq} = \frac{\text{mg} \times \text{valence}}{\text{atomic, molecular or formula weight}}$$

$$\text{mg} = \frac{\text{mEq} \times \text{atomic, molecular or formula weight}}{\text{valence}}$$

$$\text{Equiv Weight (g)} = \frac{\text{atomic, molecular or formula weight}}{\text{valence}}$$

Calculations with Milliequivalents

- Converting milliequivalents to weight
- Converting weight to milliequivalents
- Converting mg% to mEq/L

Listing of Atomic Weights, Valences, and Equivalent Weights for Common Ions

	Atomic/Formula Weight	Valence	Equiv Wt (Atomic/valence)
Al^{+++}	27	3	9
NH_4^+	18	1	18
Ca^{++}	40	2	20
Fe^{+++}	56	3	18.7
Mg^{++}	24	2	12
K^+	39	1	39
Na^+	23	1	23
$\text{C}_2\text{H}_3\text{O}_3^-$	59	1	59
HCO_3^-	61	1	61
CO_3^{--}	60	2	30
Cl^-	35.5	1	35.5
SO_4^-	96	2	48

Converting Milliequivalents to Weight

What is the concentration of a solution containing 4 mEq/L of KCl?

Step 1: Calculate the molecular weight of KCl

MW of potassium (K) = 39

MW of chloride (Cl) = 35.5

MW KCl = MW K + MW Cl = 39 + 35.5 = 74.5 g

Step 2: Calculate equivalent weight

Equiv weight = molecular weight KCl divided by valence

Since valence of KCl = 1, Equiv weight = 74.5 / 1

Step 3: 1 mEq KCl = 1/1000 x 74.5 g = 0.0745 g = 74.5 mg

Step 4: 4 mEq KCl = 74.5mg x 4 = 298 mg/ml

OR using the equation listed before:

$$\text{mg} = \frac{\text{mEq} \times \text{atomic, molecular or formula weight}}{\text{valence}}$$

$$\text{mg/ml} = \frac{\text{mEq/ml} \times \text{atomic, molecular or formula weight}}{\text{valence}} = \frac{(4 \times 74.5)}{1} = 298 \text{ mg / ml}$$

Converting Weight to Milliequivalents

How many mEq of KCl are in 1.5g of KCl?

Step 1: Calculate the molecular weight of KCl

MW of potassium (K) = 39

MW of chloride (Cl) = 35.5

MW KCl = MW K + MW Cl = 39 + 35.5 = 74.5 g

Step 2: Calculate equivalent weight

Equiv weight = molecular weight KCl divided by valence

Since valence of KCl = 1, Equiv weight = 74.5/ 1

Step 3: 1 mEq KCl = 1/1000 x 74.5 g = 0.0745 g = 74.5 mg

Step 4: 1 mEq KCl = 74.5 mg; 1.5 g KCl = 1500 mg; How many mEq in 1500 mg?

$$\frac{1mEq}{XmEq} = \frac{74.5mg}{1500mg} \quad X = 20.1 \text{ mEq}$$

Converting mg% to mEq/L

Convert the expression 10 mg% of Ca⁺⁺ to mEq/L

Step 1: Calculate the atomic weight of Ca⁺⁺

Atomic weight of Ca⁺⁺=40

Step 2: Calculate equivalent weight

Equiv weight = molecular weight Ca⁺⁺ divided by valence

Since valence of Ca⁺⁺ = 2, Equiv weight = 40/2 = 20 g

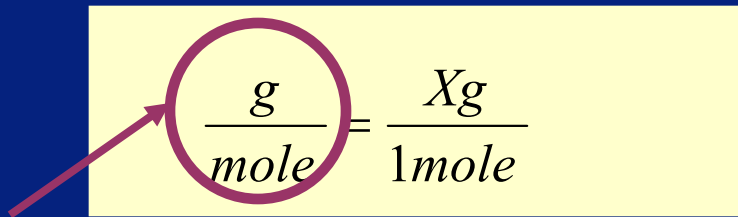
Step 3: 1 mEq Ca⁺⁺ = 1/1000 x 20 g = 0.020 g = 20 mg

Step 4: 10 mg% Ca⁺⁺= 10 mg/100ml = 100 mg per liter

$$\frac{20mg}{1mEq} = \frac{100mg}{XmEq} \quad X = 5 \text{ mEq/L}$$

Millimoles

- Remember:
 - Molecular Weight = g/mole
 - Millimole = 1/1000 of a mole
- Key Equation (by definition):

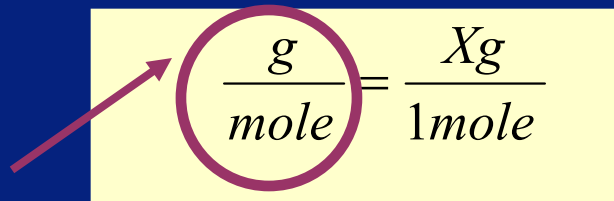

$$\frac{g}{mole} = \frac{Xg}{1mole}$$

Molecular WT (g/m)

- Conversions to remember:
 - 1 mole = 1000 millimoles
 - g/mole = mg/millimole

Millimoles Example

- Calculating amount
 - How many milligrams of monobasic sodium phosphate (MW 138) are in 1 millimole


$$\frac{g}{mole} = \frac{Xg}{1mole}$$

Molecular WT (g/m)

Since the Molecular Wt is 138

$$\frac{138 g}{mole} = \frac{Xg}{1mole} \quad X = 138 g \text{ in } 1 \text{ mole}$$

$$1 \text{ millimole} = 0.138 g = 138 \text{ mg}$$

Osmolarity vs Osmolality

- Measures of osmotic concentration
- Osmolarity: millimoles of solute per liter of solution
- Osmolality: millimoles of solute per kilogram of solvent
- Osmolarity is NOT ALWAYS equivalent to Osmolality (beware of terminology!)

Osmolarity

$$\text{mOsmol/L} = \frac{\text{wt of substance (g/L)}}{\text{MW (g)}} \times \text{number of species} \times 1000$$

Osmolarity

How many milliosmoles are in 1 liter of 10 mg% Ca⁺⁺?

Remember:

$$\text{mOsmol/L} = \frac{\text{wt of substance (g/L)}}{\text{MW (g)}} \times \text{number of species} \times 1000$$

Step 1: Identify the atomic weight of Ca⁺⁺ (Atomic weight of Ca⁺⁺=40)

Step 2: 10 mg% Ca⁺⁺= 10 mg/100ml = 100 mg per liter

Step 3: 10 mg% Ca⁺⁺= 10 mg/100ml = 100 mg per liter= 0.1 g/L

Step 4:

$$\text{mOsmol/L} = \frac{0.1 \text{ (g/L)}}{40 \text{ (g)}} \times 1 \times 1000 = 2.5 \text{ mOsm/L}$$

Therefore in each liter of 10mg% of Ca⁺⁺ there are 2.5 mOsm

Conclusions

- Simple approaches can be used to convert to amount (or concentration) expressed in metric units such as grams or g/L to mEq, mmoles or mOsm.
- Pharmacists should understand
 - The difference between mg (mg/ml), mEq, mmoles and mOsm
 - How to convert between the various units of measures