Chemistry for the Pharmacy Technician

electrolytes dissolved mineral salts, commonly found in IV fluids

Many IV fluids used in pharmacy practice contain dissolved mineral salts called **electrolytes** because they conduct an electrical charge. Electrolytes in IV solutions and certain oral drugs are measured in both metric units such as milliliters, millimoles (mM), and milliequivalents (mEq). These measures are particularly important in working in the hospital pharmacy with IV solutions. Common examples of additives to IV or TPN solutions would include potassium, sodium, and calcium chloride.

Working with electrolytes is challenging and requires some basic chemistry knowledge as well as mathematical prowess. This tutorial is designed for those pharmacy technicians who will be compounding sterile products in a hospital (or home healthcare) pharmacy setting. An understanding of electrolytes and milliequivalents will enhance the expertise of the pharmacy technician and may minimize calculation errors.

Understanding Millimoles and Milliequivalents

atomic weight the weight of a single atom of that element compared with the weight of one atom of hydrogen

molecular weight the sum of the atomic weights of all the atoms in one molecule of a compound

millimole (mM) a molecular weight, expressed as milligrams

valence the number that represents an element's capacity to combine to form a molecule of a stable compound

mole (M) the measurement of an element equal to its atomic weight in grams

equivalent (Eq) a mole divided by its valence, or the number of grams of solute dissolved in 1 mL of solution

milliequivalent (mEq) a millimole divided by its valence

Most electrolyte solutions are measured by milliequivalents (mEq), which are related to molecular weight. Molecular weights are based on the atomic weights of common elements. You may recall the *periodic elements table* posted on the wall in your chemistry class. The **atomic weight** of an element is the weight of a single atom of that element compared with the weight of one atom of hydrogen. The **molecular weight** of a compound is the sum of the atomic weights of all the atoms in one molecule of the compound. A **millimole (mM)** is the molecular weight expressed as milligrams.

Remember that electrolytes carry an electrical charge in solution. In a stable compound, the number of positive electrical charges must equal the number of negative charges. Thus salt is a sodium chloride compound consisting of both sodium (positive electrical charge) and chloride (negative electrical charge).

The **valence** of an element is a number that represents its capacity to combine to form a molecule of a stable compound. An element can exist in various forms. Valence may vary depending on an elemental form. Table 1 lists the valences and atomic weights of common elements. For pharmaceutical calculations, atomic weights are usually rounded to the nearest tenth (i.e., one unit to the right of the decimal point), as shown in the fourth column of the table.

One **mole (M)** of an element is equal to its atomic weight in grams. Thus 1 M of sodium (Na) is equal to 22.9898 g, which is typically rounded to 23 g. Compounds are also measured in moles. For example, the atomic weight of 1 M of salt or sodium chloride (NaCl) would equal the sum of the weight of its components.

$$\text{atomic weight of sodium (23 g)} + \text{atomic weight of chlorine (35.5 g)} = 58.5\text{ g}$$

As stated before, 1 mM is the molecular weight expressed in milligrams. Because 1 g equals 1000 mg, 1 M equals 1000 mM. Thus 1 mM of sodium chloride equals 58.5 mg.

One **equivalent (Eq)** is equal to 1 M divided by its valence or the number of grams of solute dissolved in 1 mL of solution, as shown in the following formula:

$$\text{Eq} = \frac{\text{molecular weight, expressed in milligrams}}{\text{valence}}$$

One **milliequivalent (mEq)** is equal to 1 mM divided by its valence. Thus as before, 1 Eq equals 1000 mEq, or one thousandth of a gram equivalent.

TABLE 1 Valences and Atomic Weights of Common Elements

Element	Valence	Atomic Weight	Rounded Value
hydrogen (H)	1	1.008 g	1 g
carbon (C)	2, 4	12.011 g	12 g
nitrogen (N)	3, 5	14.007 g	14 g
oxygen (O)	2	15.999 g	16 g
sodium (Na)	1	22.9898 g	23 g
magnesium (Mg)	2	24.305 g	24.3 g
sulphur (S)	2, 4, 6	32.064 g	32.1 g
chlorine (Cl)	1, 3, 5, 7	35.453 g	35.5 g
potassium (K)	1	39.102 g	39.1 g
calcium (Ca)	2	40.08 g	40.1 g

Determining the Milliequivalents of Compounds

The first step in determining the number of milliequivalents of a compound is to identify the formula of the compound. The next step is to separate the formula into atoms. The atomic weight of each atom is then multiplied by the number of those atoms, the products are added together, and that sum is substituted into the formula for atomic weight.

$$\text{mEq} = \frac{\text{molecular weight, expressed in milligrams}}{\text{valence}}$$

Example 1

Magnesium has an atomic weight of 24 g. What is the weight of 1 mM?

$$1 \text{ mM} = 24 \text{ g} \div 1000 = 0.024 \text{ g} = 24 \text{ mg}$$

Example 2

Magnesium sulfate ($MgSO_4$) is often used in the Obstetrics unit to decrease preterm labor or to treat preeclampsia complications. Calculate the molecular weight of 1 mM $MgSO_4$.

Begin by calculating the weights of the elements found in magnesium sulfate.

$$\begin{aligned} Mg &= 24 \text{ g (rounded down for demonstration purposes)} \\ S &= 32 \text{ g} \\ 0_4 &= 16 \text{ g} \times 4 = 64 \text{ g} \end{aligned}$$

$$24 \text{ g} + 32 \text{ g} + 64 \text{ g} = 120 \text{ g}$$

Then, calculate the molecular weight of 1 mM of $MgSO_4$.

$$1 \text{ mM} = 120 \text{ g} \div 1000 = 0.120 \text{ g} = 120 \text{ mg}$$

Example 3

The molecular weight of magnesium sulfate ($Mg^{+} + SO_4^{--}$) is 120 mg and its valence is 2. How many milligrams does 1 mEq of magnesium sulfate weigh?

$$1 \text{ mEq} = \frac{\text{molecular weight, expressed in milligrams}}{\text{valence}}$$

$$1 \text{ mEq} = \frac{120 \text{ mg}}{2} = 60 \text{ mg}$$

Converting between Milligrams and Milliequivalents

To convert back and forth between milligrams and milliequivalents, use the following formula:

$$\text{number of milliequivalents} = \frac{\text{weight of substance, expressed in milligrams}}{\text{milliequivalent weight}}$$

This equation will be demonstrated in the following example.

Example 4

Sodium has an atomic weight of 23 mg and a valence of 1. How many milliequivalents are in 92 mg of sodium?

Step 1. Determine the weight of 1 mEq of sodium by dividing the molecular weight (from the atomic weight) by the valence.

$$1 \text{ mEq} = \frac{\text{molecular weight}}{\text{valence}} = \frac{23 \text{ mg}}{1} = 23 \text{ mg}$$

Step 2. Determine the number of milliequivalents in 92 mg of sodium.

$$\text{mEq} = \frac{\text{weight of sodium}}{\text{weight of 1 mEq}} = \frac{92 \text{ mg}}{23 \text{ mg}} = 4 \text{ mEq}$$

Measuring Electrolytes

Milliequivalents (and sometimes millimoles) are used to measure electrolytes in the bloodstream and/or in an IV preparation.

Example 5

You are requested to add 40 mEq of potassium acetate to an IV bag. Potassium acetate is available as a 4 mEq/mL solution. How many milliliters will you add to the bag?

Set up a proportion and solve for the unknown.

$$\frac{x \text{ mL}}{40 \text{ mEq}} = \frac{1 \text{ mL}}{4 \text{ mEq}}$$

$$\frac{(40 \cancel{\text{mEq}})\, x \text{ mL}}{\cancel{40 \text{ mEq}}} = \frac{(40 \cancel{\text{mEq}})\, 1 \text{ mL}}{4 \cancel{\text{mEq}}}$$

$$x \text{ mL} = \frac{40 \text{ mL}}{4} = 10 \text{ mL}$$