Electrolytes Solution

Substances that are not dissociated in solution are called nonelectrolytes, and those with varying degrees of dissociation are called electrolytes. Urea and dextrose are examples of nonelectrolytes in body water; sodium chloride in body fluids is an example of an electrolyte.

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$^-$.

Function of 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, used to express the concentration of electrolytes in solution. This unit of measure is related to the total number of ionic charges in solution, and valence of the ions.

In other words, it is a unit of measurement of the amount of chemical activity of an electrolyte, milliequivalent is used mostly in the united states

In the International System (SI), molar concentrations [as milli-moles 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.

So 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.

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

A milliequivalent represents the amount, in milligrams, of a solute equal to 1⁄1000 of its gram equivalent weight, taking into account the valence of the ions.

TABLE 12.2 USUAL REFERENCE RANGE OF BLOOD SERUM VALUES FOR SOME ELECTROLYTES[a]

CATION/ANION	mEq/L	SI UNITS (mmol/L)
Sodium	135–145	135–145
Potassium	3.5–5.5	3.5–5.5
Calcium	4.6–5.5	2.3–2.75
Magnesium	1.5–2.5	0.75–1.25
Chloride	96–106	96–106
Carbon Dioxide	24–30	24–30
Phosphorus	2.5–4.5	0.8–1.5

[a] Reference ranges may vary slightly between clinical laboratories based, in part, on the analytical methods and equipment used.

Thus, based on the atomic weight and valence of the species, 1 mEq is represented by 1 mg of hydrogen, 20 mg of calcium, 23 mg of sodium, 35.5 mg of chlorine, 39 mg of potassium and so forth.

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 $= \dfrac{\text{Atomic or formula weight}}{\text{Valence}}$

Calculation of milliequivalents

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

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

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

Examples calculation of milliequivalents

What is the concentration, in milligrams per milliliter, of a solution containing 2 mEq of potassium chloride (KCl) per milliliter(molecular weight of KCl=74.5)?

$$\text{Molecular weight of KCl} = 74.5$$
$$\text{Equivalent weight of KCl} = 74.5$$
$$1 \text{ mEq of KCl} = \tfrac{1}{1000} \times 74.5 \text{ g} = 0.0745 \text{ g} = 74.5 \text{ mg}$$
$$2 \text{ mEq of KCl} = 74.5 \text{ mg} \times 2 = 149 \text{ mg/mL}, \textit{ answer.}$$

Or, by using the preceding equation:

$$\text{mg/mL} = \frac{2 \text{ (mEq/mL)} \times 74.5}{1}$$
$$= 149 \text{ mg/mL}, \textit{ answer.}$$

What is the concentration, in grams per milliliter, of a solution containing 4 mEq of calcium chloride ($CaCl_2 \cdot 2H_2O$) per milliliter(M.wt= 147)?

$$\text{Formula weight of } CaCl_2 \cdot 2H_2O = 147$$
$$\text{Equivalent weight of } CaCl_2 \cdot 2H_2O = {}^{147}\!/_2 = 73.5$$
$$1 \text{ mEq of } CaCl_2 \cdot 2H_2O = \tfrac{1}{1000} \times 73.5 \text{ g} = 0.0735 \text{ g}$$
$$4 \text{ mEq of } CaCl_2 \cdot 2H_2O = 0.0735 \text{ g} \times 4 = 0.294 \text{ g/mL}, \textit{ answer.}$$

Or, solving by dimensional analysis:

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

What is the percent (w/v) concentration of a solution containing 100 mEq of ammonium chloride per liter (M.wt= 53.5)?

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

A solution contains 10 mg/100 mL of K^+ ions. Express this concentration in terms of milliequivalents per liter (atomic weight of K^+=39).

$$\begin{aligned} \text{Atomic weight of } K^+ &= 39 \\ \text{Equivalent weight of } K^+ &= 39 \\ 1 \text{ mEq of } K^+ &= \tfrac{1}{1000} \times 39 \text{ g} = 0.039 \text{ g} = 39 \text{ mg} \\ 10 \text{ mg/100 mL of } K^+ &= 100 \text{ mg of } K^+ \text{ per liter} \\ 100 \text{ mg} \div 39 &= 2.56 \text{ mEq/L, } \textit{answer.} \end{aligned}$$

Or, by the equation detailed previously:

$$\begin{aligned} \text{mEq/L} &= \frac{100 \text{ (mg/L)} \times 1}{39} \\ &= 2.56 \text{ mEq/L, } \textit{answer.} \end{aligned}$$

A solution contains 10 mg/100 mL of Ca^{++} ions. Express this concentration in terms of milliequivalents per liter (atomic weight=40).

$$\begin{aligned} \text{Atomic weight of } Ca^{++} &= 40 \\ \text{Equivalent weight of } Ca^{++} &= \tfrac{40}{2} = 20 \\ 1 \text{ mEq of } Ca^{++} &= \tfrac{1}{1000} \times 20 \text{ g} = 0.020 \text{ g} = 20 \text{ mg} \\ 10 \text{ mg/100 mL of } Ca^{++} &= 100 \text{ mg of } Ca^{++} \text{ per liter} \\ 100 \text{ mg} \div 20 &= 5 \text{ mEq/L, } \textit{answer.} \end{aligned}$$

A magnesium (Mg^{++}) level in blood plasma is determined to be 2.5 mEq/L. Express this concentration in terms of milligrams (atomic weight=24).

$$\begin{aligned} \text{Atomic weight of } Mg^{++} &= 24 \\ \text{Equivalent weight of } Mg^{++} &= \tfrac{24}{2} = 12 \\ 1 \text{ mEq of } Mg^{++} &= \tfrac{1}{1000} \times 12 \text{ g} = 0.012 \text{ g} = 12 \text{ mg} \\ 2.5 \text{ mEq of } Mg^{++} &= 30 \text{ mg} \\ & 30 \text{ mg/L, } \textit{answer.} \end{aligned}$$

How many milliequivalents of potassium chloride are represented in a 15-mL dose of a 10% (w/v) potassium chloride elixir (M.wt= 74.5)?

Molecular weight of KCl = 74.5
Equivalent weight of KCl = 74.5
1 mEq of KCl = $\frac{1}{1000} \times 74.5$ g = 0.0745 g = 74.5 mg
15-mL dose of 10% (w/v) elixir = 1.5 g or 1500 mg of KCl

$$\frac{74.5 \text{ (mg)}}{1500 \text{ (mg)}} = \frac{1 \text{ (mEq)}}{x \text{ (mEq)}}$$

x = 20.1 mEq, *answer.*

How many milliequivalents of magnesium sulfate are represented in 1 g of anhydrous magnesium sulfate ($MgSO_4$) (M.wt= 120)?

Molecular weight of $MgSO_4$ = 120
Equivalent weight of $MgSO_4$ = 60
1 mEq of $MgSO_4$ = $\frac{1}{1000} \times 60$ g = 0.06 g = 60 mg
1.0 g of $MgSO_4$ = 1000 mg

$$\frac{60 \text{ (mg)}}{1000 \text{ (mg)}} = \frac{1 \text{ (mEq)}}{x \text{ (mEq)}}$$

x = 16.7 mEq, *answer.*

A person is to receive 2 mEq of sodium chloride per kilogram of body weight. If the person weighs 132 lb., how many milliliters of a 0.9% sterile solution of sodium chloride should be administered?

Molecular weight of NaCl = 58.5
Equivalent weight of NaCl = 58.5
1 mEq of NaCl = $\frac{1}{1000} \times 58.5$ g = 0.0585 g
2 mEq of NaCl = 0.0585 g × 2 = 0.117 g

1 kg = 2.2 lb. Weight of person in kg = $\frac{132 \text{ lb.}}{2.2 \text{ lb.}}$ = 60 kg

Because the person is to receive 2 mEq/kg, then 2 mEq or 0.117 g × 60 = 7.02 g of NaCl needed and because 0.9% sterile solution of sodium chloride contains

9 g of NaCl per liter,

then

$$\frac{9 \text{ (g)}}{7.02 \text{ (g)}} = \frac{1000 \text{ (mL)}}{x \text{ (mL)}}$$

x = 780 mL, *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

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

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

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

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

$$1 \text{ mEq} = \tfrac{1}{1000} \times 134 \text{ g} = 0.134 \text{ g} = 134 \text{ mg}$$

$$\frac{134\text{ (mg)}}{5400\text{ (mg)}} = \frac{1\text{ (mEq)}}{x\text{ (mEq)}}$$

$$x = 40.3 \text{ mEq of disodium hydrogen phosphate}$$

Because the milliequivalent value of Na^+ ion equals the milliequivalent value of disodium hydrogen phosphate, then

$$x = 40.3 \text{ mEq of } Na^+$$

Sodium biphosphate

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

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

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

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

$$1 \text{ mEq} = \tfrac{1}{1000} \times 138 \text{ g} = 0.138 \text{ g} = 138 \text{ mg}$$

$$\frac{138\text{ (mg)}}{14{,}400\text{ (mg)}} = \frac{1\text{ (mEq)}}{x\text{ (mEq)}}$$

$$x = 104.3 \text{ mEq of sodium biphosphate}$$

$$\text{and also,} = 104.3 \text{ mEq of } Na^+$$

Adding the two milliequivalent values for Na^+ = 40.3 mEq + 104.3 mEq = 144.6 mEq, *answer.*

Millimoles and micromoles

The SI expresses electrolyte concentrations in millimoles per liter (mmol/L) in representing the combining power of a chemical species. For monovalent species, the numeric values of the milliequivalent and millimole are identical.

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.

Example Calculations of Millimoles and Micromoles

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

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

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

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

What is the weight, in milligrams, of 1 mmol of HPO4^{-}?

$$\begin{aligned} \text{Atomic weight of } HPO_4^{=} &= 95.98 \\ 1 \text{ mole of } HPO_4^{=} &= 95.98 \text{ g} \\ 1 \text{ mmol of } HPO_4^{=} &= 95.98 \text{ g} \times \frac{1}{1000} = 0.09598 \text{ g} \\ &= 95.98 \text{ mg, } \textit{answer.} \end{aligned}$$

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

By dimensional analysis:

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

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

Is the milliosmoles of solute per liter of solution. The labels of pharmacopeial solutions that provide intravenous replenishment of fluid, nutrients, or electrolytes, and the osmotic diuretic mannitol are required to state the osmolar concentration.

This indicate whether the solution is hypoosmotic, iso-osmotic, or hyperosmotic with regard to biologic fluids and membranes.

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.

According to the United States Pharmacopeia, the ideal osmolar concentration may be calculated according to the equation:

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

In practice, as the concentration of the solute increases, physicochemical interaction among solute particles increases, and actual osmolar values decrease when compared to ideal values.
For example, the ideal osmolarity of 0.9% sodium chloride injection is:

$$\text{mOsmol/L} = \frac{9\ \text{g/L}}{58.5\ \text{g}} \times 2 \times 1000 = 308\ \text{mOsmol/L}$$

Because of bonding forces, however, n is slightly less than 2 for solutions of sodium chloride at this concentration, and the actual measured osmolarity of the solution is about 286 mOsmol/L.

Osmolality

Is the milliosmoles of solute per kilogram of solvent. For dilute aqueous solutions, osmolarity and osmolality are nearly identical. For more concentrated solutions, however, the two values may be quite dissimilar.
Normal serum osmolality is considered to be within the range of 275 to 300 mOsmol/kg. Osmometers are commercially available for use in the laboratory to measure osmolality.
Abnormal blood osmolality can occur in

- shock,
- trauma,
- burns,
- water intoxication (overload),
- electrolyte imbalance,
- hyperglycemia,
- renal failure.

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?

Formula weight of anhydrous dextrose = 180
1 mmol of anhydrous dextrose (180 mg) = 1 mOsmol
5% solution contains 50 g or 50,000 mg/L
50,000 mg ÷ 180 = 278 mOsmol/L, *answer.*

Or, solving by dimensional analysis:

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

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

Atomic weight of K^+ = 39
1 mmol of K^+ (39 mg) = 1 mOsmol
156 mg of K^+ per 100 mL = 1560 mg of K^+ per liter
1560 mg ÷ 39 = 40 mOsmol, *answer.*

A solution contains 10 mg% of Ca^{++} ions. How many milliosmoles are represented in 1 liter of the solution?

Atomic weight of Ca^{++} = 40
1 mmol of Ca^{++} (40 mg) = 1 mOsmol
10 mg% of Ca^{++} = 10 mg of Ca^{++} per 100 mL or 100 mg of Ca^{++} per liter
100 mg ÷ 40 = 2.5 mOsmol, *answer.*

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

$$\text{Formula weight of NaCl} = 58.5$$
$$1 \text{ mmol of NaCl } (58.5 \text{ mg}) = 2 \text{ mOsmol}$$
$$1000 \times 0.009 = 9 \text{ g or } 9000 \text{ mg of NaCl per liter}$$
$$\frac{58.5 \text{ (mg)}}{9000 \text{ (mg)}} = \frac{2 \text{ (mOsmol)}}{x \text{ (mOsmol)}}$$
$$x = 307.7, \text{ or } 308 \text{ mOsmol, } \textit{answer.}$$

Clinical consideration of water and electrolyte balance

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.

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.

Cases need fluid and electrolyte therapy

- 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.

Total body water in adult males normally ranges between 55% and 65% of body weight depending on the proportion of body fat. Values for adult women are about 10% less than those for men. Newborn infants have approximately 75% body water.

The composition of body fluids generally is described with regard to body compartments:

- intracellular (within cells),
- intravascular (blood plasma),
- or interstitial (between cells in the tissue).

Intravascular and interstitial fluids commonly are grouped together and termed extracellular fluid.

Although all electrolytes and nonelectrolytes in body fluids contribute to osmotic activity,

- sodium and chloride exert the principal effect in extracellular fluid,
- potassium and phosphate predominate in intracellular fluid.

Since cell membranes generally are freely permeable to water, the osmolality of the extracellular fluid (about 290 mOsm/kg water) is about equal to that of the intracellular fluid.

Therefore, the plasma osmolality is a convenient and accurate guide to intracellular osmolality and may be approximated by the formula

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

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).

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 m2.

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

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

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

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.

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

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

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

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

Calculate the milliequivalents of sodium, potassium and chloride, the millimoles of anhydrous dextrose, and the osmolarity of the following parenteral fluid.

Dextrose, anhydrous	50 g
Sodium Chloride	4.5 g
Potassium Chloride	1.49 g
Water for Injection, ad	1000 mL

Molecular weight of NaCl = 58.5
Equivalent weight of NaCl = 58.5
1 mEq of NaCl = $^1/_{1000} \times 58.5 = 0.0585$ g = 58.5 mg
4.5 g of NaCl = 4500 mg

$$\frac{58.5 \text{ mg}}{4500 \text{ mg}} = \frac{1 \text{ mEq}}{x \text{ mEq}}$$

x = 76.9 or 77 mEq of Na^+ and
76.9 or 77 mEq of Cl^-

Molecular weight of KCl = 74.5
Equivalent weight of KCl = 74.5
1 mEq of KCl = $^1/_{1000} \times 74.5 = 0.0745$ g = 74.5 mg
1.49 g of KCl = 1490 mg

$$\frac{74.5 \text{ mg}}{1490} = \frac{1 \text{ mEq}}{x \text{ mEq}}$$

x = 20 mEq of K^+ and
20 mEq of Cl^-

Total: Na^+ = 77 mEq
K^+ = 20 mEq
Cl^- = 77 mEq + 20 mEq = 97 mEq, *answers.*

Molecular weight of anhydrous dextrose = 180
1 mmol of anhydrous dextrose = 180 mg
50 g of anhydrous dextrose = 50,000 mg

$$\frac{180 \text{ mg}}{50{,}000 \text{ mg}} = \frac{1 \text{ mmol}}{x \text{ mmol}}$$

x = 277.7 or 278 mmol, *answer.*

Osmolarity:

Dextrose, anhyd.: 278 mmol × 1 particle per mmol = 278 mOsmol
NaCl: 77 mEq × 2 particles per mEq (or mmol) = 154 mOsmol
KCl: 20 mEq × 2 particles per mEq (or mmol) = 40 mOsmol
Total = 472 mOsmol, *answer.*

CALCULATIONS CAPSULE

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.

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

CASE IN POINT 12.1[6]: A hospital pharmacist fills a medication order calling for an intravenous fluid of dextrose 5% in a 0.9% sodium chloride injection and 40 mEq of potassium chloride in a total volume of 1000 mL. The intravenous infusion is administered through an IV set that delivers 15 drops per milliliter. The infusion has been running at a rate of 12 drops per minute for 15 hours.

During the 15-hour period:

(a) How many mEq of KCl have been administered?

(b) How many grams of KCl have been administered?

(c) How many millimoles of KCl have been administered?

(d) What is the total osmolarity of the intravenous fluid?

Express the answer in millimoles (rounded to the nearest whole number) per 1000 mL.