Calculating Osmolarity in Complex Solutions:

As described under Units of Measure, the osmolarity of a simple solution is equal to the molarity times the number of particles per molecule.

- Glucose has 1 particle
- NaCl has two
- MgCl2 has three.

Real solutions can be much more complex:

- Proteins with many equivalents/L may only contribute a small amount to the osmolarity, since they consist of a few very large "particles".
- Not all the solution volume is aqueous. For example, plasma has 7% dissolved proteins and lipids.
- Not all ions are free in a solution. Cations may be bound to other anions or to proteins.
- For complete accuracy, all constituents should be included in the calculation.

Shortcut:

The difficulties given above leave many uncertainties when calculating the osmolarity of a solution like plasma.

Plasma osmolarity can be estimated easily, however: **Take the reported Na concentration (mEq/Liter Plasma) and double it**. This obviously erroneous calculation (given all of the above) comes very close, since the errors tend to cancel each other!

In some clinical settings, one must also account for the effects of elevated plasma glucose or urea.

Osmolarity vs. Tonicity:

Osmolarity measures the effective gradient for water **assuming that all the osmotic solute is completely impermeant.** It is simply a count of the number of dissolved particles. Therefore a 300 millimolar solution of glucose, a 300 millimolar solution of urea, and a 150 millimolar solution of NaCl each have the same osmolarity.

A cell, placed in each of these solutions, would behave very differently, however. In a 150 mM NaCl solution, there would be equal osmotic strengths on both sides (NaCl is impermeant), and the cell would maintain the same volume.

Urea is very permeable through most cell membranes. It exerts little osmotic force against a real cell and its membrane. A cell placed in 300 mM urea would rapidly swell as both urea and water entered the cell down their activity gradients.

Tonicity is a functional term that describes the tendency of a solution to resist expansion of the intracellular volume.

Two solutions are **isosmotic** when they have the same number of dissolved particles, regardless of how much water would flow across a given membrane barrier. In contrast, two solutions are **isotonic** when they would cause no water movement across a membrane barrier, regardless of how many particles are dissolved.

In the example given above, a 150 mM NaCl solution would be isosmotic to the inside of a cell, **and it would also be isotonic**--the cell would not swell or shrink when placed in this solution. On the other hand, a 300 mM urea solution, while still isosmotic would cause the cell to swell and burst (due to its permeability). This isosmotic ureas solution is **not isotonic**. Instead it has a lower tonicity (called hypotonic).

Molarity vs Osmolarity

Sodium Cloride = NaCl = (23 x 1) + (35.2 x1) = 58.2 MW

Glucose = C6H12O6 = (12 x 6) + (1 x 12) + (16 x 6) = 180 MW

Magnesium Cloride = MgCl2 = (24 x 1) + (35 x 2) = 94 MW

Avogadro's Number = 6.02 x 10 power of 23 / (Number of particles in one mole.)

What is the osmolarity of the above compounds?