

Answer Key - Quantitative Question from Lecture #10

$$(a) \mu = \frac{1}{2} \sum_i M_i z_i^2$$

$$\mu_{1M \text{ NaCl}} = [(1) (+1)^2 + (1) (-1)^2] / 2 = \boxed{1}$$

$$\mu_{1M \text{ (NH}_4\text{)}_2\text{SO}_4} = [(2) (+1)^2 + (1) (-2)^2] / 2 = \boxed{3}$$

Thus, even though both solutes are present at the same molarity, the solution of ammonium sulfate has an ionic strength (and hence a capacity to shield the effects of other ions, e.g. those on the surface of globular proteins) that is three times higher than that of the solution of sodium chloride.

(b) The "sphere of influence" of a charged side chain on a protein (its Debye length) is inversely proportional to the ionic strength. Thus, in solutions of low ionic strength, the effective distance over which a charge can act will be large. For example, in a solution of 10 mM NaCl at 25°C, $1/b = 31 \text{ \AA}$, which is as large as, or larger, than the radius of an average globular protein. Hence, such an unshielded charge will attract even distant charges of opposite sign on other proteins in the same solution. Therefore, under these conditions, essentially all globular proteins will aggregate and precipitate. By contrast, when the ionic strength is raised, $1/b$ is decreased. For example, in a solution of 1 M NaCl at 25°C, $1/b = 3.1 \text{ \AA}$, which is on an order of magnitude such that the effect of a charged group will be felt only within the globular protein that contains it. Thus, essentially all globular proteins require at least some moderate amount of salt in the purification and/or assay buffer to remain soluble (prevent aggregation) and to maintain the normal contacts necessary for its native conformation (so it can remain biologically active).