

1. **Effect of Local Environment on Ionic Bond Strength** If the ATP-binding site of an enzyme is buried in the interior of the enzyme, in a hydrophobic environment, is the ionic interaction between enzyme and substrate stronger or weaker than that same interaction would be on the surface of the enzyme, exposed to water? Why?

Answer The strength, or force (F), of ionic interactions in a solution depends on the magnitude of the charges (Q), the distance between the charged groups (r), and the dielectric constant (ϵ , which is dimensionless) of the solvent in which the interactions occur, according to the following equation:

$$F = \frac{Q_1Q_2}{4\pi r^2 \epsilon}$$

When comparing the strength of the same ionic bond in water and in the hydrophobic environment inside a protein, we know that Q and r are the same; only ϵ is different. Water has a large dielectric constant because of the large number of dipoles. A hydrophobic “solvent” such as the inside of a protein has a much smaller dielectric constant. Given that the strength of the ionic interaction (F) varies as the inverse of the dielectric constant (ϵ), the ionic interaction would be stronger in the protein environment, with the smaller dielectric constant.

2. **Biological Advantage of Weak Interactions** The interactions between biomolecules are often stabilized by weak interactions such as hydrogen bonds. How might this be an advantage to the organism?

Answer Weak interactions are biologically advantageous in many ways. Collectively, many weak interactions can be stronger than one or a few stronger bonds. Biomolecular interactions need to be both specific and reversible. Many weak interactions can allow a high specificity of binding. At the same time, many biomolecular interactions are, of necessity, transient. A small change in conformation or in the environment (pH, ionic strength, or the presence or absence of a divalent cation, for example) can sufficiently alter the strength of weak bonds to allow the interactions between molecules to be reversible.

3. **Solubility of Ethanol in Water** Explain why ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) is more soluble in water than is ethane (CH_3CH_3).

Answer Ethanol is polar; ethane is not. The ethanol $-\text{OH}$ group can hydrogen-bond with water.

4. **Calculation of pH from Hydrogen Ion Concentration** What is the pH of a solution that has an H^+ concentration of **(a)** 1.75×10^{-5} mol/L, **(b)** 6.50×10^{-10} mol/L, **(c)** 1.0×10^{-4} mol/L, **(d)** 1.50×10^{-7} mol/L?

Answer Using $\text{pH} = -\log [\text{H}^+]$:

(a) $-\log (1.75 \times 10^{-5}) = 4.75$; **(b)** $-\log (6.50 \times 10^{-10}) = 9.19$; **(c)** $-\log (1.0 \times 10^{-4}) = 4.0$;
(d) $-\log (1.50 \times 10^{-7}) = 6.82$.

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Albert Lehninger



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