

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 ( $\epsilon$ , which is dimensionless) of the solvent in which the interactions occur, according to the following equation:

$$F = \frac{Q_1 Q_2}{\epsilon r^2}$$

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  $\epsilon$  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 ( $\epsilon$ ), 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 ( $\text{CH}_3\text{CH}_3$ ).

**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  $\text{H}^+$  concentration of **(a)**  $1.75 \times 10^{-5} \text{ mol/L}$ ; **(b)**  $6.50 \times 10^{-10} \text{ mol/L}$ ; **(c)**  $1.0 \times 10^{-4} \text{ mol/L}$ ; **(d)**  $1.50 \times 10^{-5} \text{ mol/L}$ ?

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

**(a)**  $-\log (1.75 \times 10^{-5}) = 4.76$ ; **(b)**  $-\log (6.50 \times 10^{-10}) = 9.19$ ; **(c)**  $-\log (1.0 \times 10^{-4}) = 4.0$ ; **(d)**  $-\log (1.50 \times 10^{-5}) = 4.82$ .

# Lehninger Solution Manual

**Albert Lehninger**



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