***Solutions to  
End-of-Chapter Problems***

Chapter 2  
The Chemical Foundation of Life: Weak Interactions in an Aqueous Environment

**1.** **a.** Equation 2.3 predicts that the interaction energy between the ions will be greater in the lower dielectric medium; thus, the attraction between the  and  will be greater in pentane.

**b.** Since the length of the ionic bonds is Å in each case (i.e., the value of *r* is the same for Ca-F and Na-F), Equation 2.3 predicts that the interaction energy between the ion will be greater as the values of *q* increase; thus, the attraction between the  and  will be greater than the attraction between the  and 

**c.** Ca2 will be bound more tightly by a COOH group that is fully deprotonated. At pH  3 the COOH form will predominate. At pH  4.2 the COOH and COO− forms will be in equal concentration. At pH 8 the COO− will predominate; thus, expect greatest Ca2 binding at pH  8.

**2.** In the upper pair NH is the donor and O is the acceptor. This is the more likely interaction. In the lower pair, the one NH is the donor and the other N is the acceptor.

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**3.** The curve shown in the question describes the situation where the water dipoles are parallel and side by side. Assuming the antiparallel dipoles are also side by side (rather than head to tail), the curve would be the mirror image reflected across the Energy  0 line on the y-axis.

**4.** **a.** HCl is a strong acid; thus, [HCl]  [H] and pH  log[H]  log[0.35]  0.456

**b.** Acetic acid is a weak acid with *K*a  1.74 × 10−5; thus, use ICE table to solve this problem:

|  |  |  |  |
| --- | --- | --- | --- |
| H2O  CH3COOH  H3O  CH3COO− | | | |
|  | CH3COOH | H | CH3COO− |
| **Initial** | 0.35 M | 0 M | 0 M |
| **Change** | *x* | *x* | *x* |
| **Equilibrium** | 0.35  *x* M | *x* M | *x* M |



Assume [CH3COO−]  [H3O] and [CH3COOH] >> *x*; therefore:





pH  log(2.47 × 10−3)  2.61

This answer verifies the initial assumption that [CH3COOH] >> *x*.

**c.** Here [CH3COOH] >> *x* cannot be assumed, so use ICE table approach with the quadratic equation to solve this problem:



Rearrange to



Solve using the quadratic equation:



 thus, pH  log[7.717 × 10−4]  3.11

**d.** pH is lowest for the strongest acid (HCl) because it completely dissociates into H   
and conjugate base (i.e., Cl−). For acetic acid, more H dissociates as the concentration   
of HA increases. This follows from Le Chatelier’s principle for the equilibrium: 

**5. a.** See Table 2.6, which indicates that  is a weak acid with *K*a  5.62 × 10−10; thus, use ICE table to solve this problem (note that the “initial” conditions here are hypothetical; we imagine a starting concentration of  of 1 M and assume that the final concentration of H from dissociation of NH4 will be significantly greater than 10−7 M, which results from the autolysis of water):

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
|  |  | H | NH3 |
| **Initial** | 1 M |  0 M | 0 M |
| **Change** | *x* | *x* | *x* |
| **Equilibrium** | 1  *x* M | *x* M | *x* M |



Solve for *x*  2.371 × 10−5  [H]; thus pH  log(2.371 × 10−5)  4.63

**b.**  is a weak acid with p*K*a  9.25. Here, NaOH is consuming H from the    
thus, use this alternate version of the ICE table to solve for [HA] and [A−] after   
addition of NaOH (a source of −OH). Note: the activity of H2O is assumed to   
be unity (see Equation 2.7), so it does not appear in these calculations.

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
|  |  | −OH | NH3 |
| **Initial** | 0.040 mol | 0.010 mol |  0 |
| **Change** | 0.010 mol | 0.010 mol | 0.010 mol |
| **Equilibrium** | 0.030 mol | 0 | 0.010 mol |

Solve for [H] using the Henderson–Hasselbalch equation:



**c.** Solve as in part (b)

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
|  |  | −OH | NH3 |
| **Initial** | 0.040 mol | 0.030 mol |  0 |
| **Change** | 0.030 mol | 0.030 mol | 0.030 mol |
| **Equilibrium** | 0.010 mol | 0 | 0.030 mol |

Solve for [H] using the Henderson–Hasselbalch equation:



**6. a.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
| **Initial** | 0.1 M | 0 | 0 |
| **Change** | *x* | *x* | *x* |
| **Equilibrium** | 0.1 M  *x* | *x* | *x* |



And



**b.** 