you-try-it-05.xlsx
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For use with:
Brian M. Tissue, *Basics of Analytical Chemistry and Chemical Equilibria,* (John Wiley: New York, 2013).
http://www.achem.org

Worksheets in this file

notes	This page with background information.
5.1 neutralization	Determining limiting reagents products of neutralization reactions.
5.2 amphiprotic-salts	Using K_a and K_b to determine acidity of amphiprotic salt solutions.
5.3 acidity	Comparing acidity (basicity) of different weak acid (weak base) solutions.
5.4 ionic-strength	Calculating ionic strength and activity coefficients.
5.5 equilibrium	Predicting p[H_3O^+] of weak acid and weak base solutions.

Background
Refer to Chapter 5 in the text for equations and explanations.
Each worksheet has instructions in the shaded box.
For step-by-step help see you-try-it-05guide.pdf.

Tables of thermodynamic K_a values for weak acids are available in:
- Appendix C of the text.
- 'K_a values' worksheet in pH-calculation.xlsx.
(Use 'Copy' and 'Paste Values' to copy values to this worksheet.)

You-Try-It 5.1 **Neutralization Reactions of Strong Acids and Strong Bases**

The table lists a series of separate solutions of strong acids and strong bases.
Neutralization is the only type of reaction that occurs when the solutions are mixed.

1. Determine if the acid or the base is the limiting reagent for each case.
   Optional: write a formula to determine the limiting reagent.
   Hint: use an IF statement to compare the number of mols of acid and base.

2. Determine if the resulting solution will be acidic, basic, or neutral.

3. Write formulas to calculate the pH of the solution when the acid and base are mixed.

Table 5.1.A

	strong acid solution			**strong base solution**		
case	**vol (L)**	**conc (M)**	**acid**	**vol (L)**	**conc (M)**	**base**
1	1.00	0.0070	HCl	1.00	0.0050	KOH
2	1.00	0.0050	HNO_3	1.00	0.0070	NaOH
3	1.00	0.0050	H_2SO_4	1.00	0.0050	LiOH
4	1.00	0.0050	H_2SO_4	1.00	0.0050	$Ca(OH)_2$
5	1.00	0.0050	$HClO_4$	1.00	0.0050	$Ca(OH)_2$
6	1.00	0.0050	H_3PO_4	1.00	0.0050	$Ca(OH)_2$

You-Try-It 5.2 **Solutions of amphiprotic salts**

The table gives examples of soluble salts.

1. Look up K_a for the weak acid cations and the conjugate acids of the weak base anions.

2. Calculate K_b values for the weak base anions.
   Determine if the resulting solution will be acidic, basic, or neutral when the salt is dissolved in water.

K_w = 1.01E-14

case	salt	cation K_a	anion K_b	K_a of conj. acid	result
1	KNO_3				
2	NH_4Cl				
3	CH_3COONa				
4	$Cu(CH_3COO)_2$				
5	NH_4F				
6	CH_3COONH_4				

You-Try-It 5.3 **Solution Acidity and Basicity**

Each row in Table 5.3.A gives two acid solutions and each row in Table 5.3.B gives two base solutions.
You may assume that all species are soluble at the concentrations in the tables.

1. Predict which solution for each case in Table 5.3.A will be most acidic, i.e., will have the lowest pH. Calculate $p[H_3O^+]$ as needed for weak acids using $[H_3O^+] \approx \text{sqrt}(c_{HA} * K_a)$.

2. Predict which solution for each case in Table 5.3.B will be most basic, i.e., will have the highest pH. No calculations are necessary.

weak acid	K_a
CH_3COOH	1.75E-05
$CHCl_2COOH$	4.47E-02
HClO	2.90E-08
NH_4Cl	5.68E-10

weak base	K_b
NH_3	1.78E-05
$C_3H_4N_2$ (imidazole)	1.02E-07

Table 5.3.A

	acid solution 1			acid solution 2			most
case	conc (M)	acid	$p[H_3O^+]$	conc (M)	acid	$p[H_3O^+]$	acidic
1	0.0050	HCl		0.0050	CH_3COOH		
2	0.0050	HNO_3		0.0500	CH_3COOH		
3	0.0050	CH_3COOH		0.0050	$CHCl_2COOH$		
4	0.0050	CH_3COOH		0.0050	HClO		
5	0.0050	CH_3COOH		0.0500	NH_4Cl		

Table 5.3.B

	base solution 1		base solution 2		most
case	conc (M)	base	conc (M)	base	basic
1	0.0010	LiOH	0.0010	$Ca(OH)_2$	
2	0.0050	NH_3	0.0050	NaOH	
3	0.0050	NH_3	0.0050	$C_3H_4N_2$	

You-Try-It 5.4 **Ionic Strength and Activity Coefficients**

1. Calculate the ionic strength, I_c, for each solution in Table 5.4.A.
   The listed concentrations are formal concentrations before any reaction occurs.
   For cases 1-7 you may assume that reaction with water does not change I_c.
   For cases 5, 6, and 8, determine the ion concentrations after reaction and then calculate I_c.

2. For cases 7 and 8 determine the activity coefficients for the ions in the equilibria.
   (Use activity-coefficients.xlsx from the text website.)
   Use the activity coefficients to find K_a' and K_b' for cases 7 and 8, respectively.

Table 5.4.A

case	conc (M)	salt	conc (M)	salt
1	0.0100	$CaCl_2$		
2	0.0100	Na_3PO_4		
3	0.0100	Na_2HPO_4		
4	0.0100	NaCl	0.0100	$CaCl_2$
5	0.0200	NaCl	0.0100	$Ba(NO_3)_2$
6	0.0500	HNO_3	0.0100	$Ca(OH)_2$
7	0.0500	NH_4Cl		
8	0.0500	NH_3		

Notes

Ca^{2+} is a borderline strong electrolyte
PO_4^{3-} is a weak base
HPO_4^{2-} is amphiprotic
Ca^{2+} is a borderline strong electrolyte
a precipitation reaction occurs
a neutralization reaction occurs
NH_4^+ is a weak acid, K_a = 5.675E-10
NH_3 is a weak base, K_b = 1.780E-5

You-Try-It 5.5 Equilibrium calculations for weak acids and weak bases

The equilibrium constants in the tables are already corrected for ionic strength.

1. Write formulas to find $[H_3O^+]$ and $p[H_3O^+]$ for the weak acid solutions in Table 5.5.A.
   Use the approximation $[H_3O^+] \approx \text{sqrt}(c_{HA}*K_a)$.
   Do the same for the weak bases in Table 5.5.B, solving for $[OH^-]$ and converting to $[H_3O^+]$.

2. Write formulas to find $[H_3O^+]$ and $p[H_3O^+]$ for the weak acid solutions in Table 5.5.A.
   Use the quadratic equation and compare your results with the approximation in question 1.

Table 5.5.A Weak Acids

case	conc (M)	acid	K_a'
1	0.0100	CH_3COOH	1.8E-05
2	0.0010	CH_3COOH	1.8E-05
3	0.0010	NH_4Cl	5.7E-10
4	0.0100	$CHCl_2COOH$	5.7E-02

Table 5.5.B Weak Bases

case	conc (M)	base	K_b'
4	0.0010	NH_3	1.8E-05
5	0.0010	NaClO	3.5E-07