

The Relationship Between an Acid's Initial Concentration and Percent Ionization

Purpose: to discover the relationship between an acid's initial concentration and percent ionization. To do so, we will rely on our algebra skills and on an Excel spreadsheet.

Procedure

1. The data will be based on nitrous acid, $\text{HNO}_{2(\text{aq})}$.
 - a) Write an equation to show what happens when it ionizes in water.
 - b) Copy the following values and column headings into an Excel spreadsheet.

Initial Concentration (write this in A1 column)	K_A value (write this in B1 column)	[H⁺] (write this in C1 column)	pH (write this in D1 column)	% ionization (write this in E1 column)
0.5	4.30E-04			
0.2	4.30E-04			
0.1	4.30E-04			
0.05	4.30E-04			
0.02	4.30E-04			
0.01	4.30E-04			
0.005	4.30E-04			
0.001	4.30E-04			
0.0005	4.30E-04			

2. Now here comes the fun part. To fill the rest of the columns without tediously repeating the same kind of calculation, we have to "tell" Excel how to figure out H^+ .

- a) First recall that after filling an ice chart we realize that $K = x^2/(y-x)$, where $x = [\text{H}^+]$, and $y =$ initial concentration of $\text{HNO}_{2(\text{aq})}$.

Fill out an ICE chart to show that this is true.

- b) Now cross multiply and bring everything to one side of the equal sign, so that you have a quadratic equation of the form $ax^2 + bx + c = 0$.

Write your result here: _____

Compare your general equation to $ax^2 + bx + c = 0$, and give numerical values or algebraic expressions for a, b, and c. The first two are done for you.

a	1	In spreadsheet language
b	K	First value is in B2
c		-A2*B2

- c) Now in the C2 cell of the spreadsheet, begin by typing an equal sign and write the quadratic formula without the x and replace the a, b, c values with the spreadsheet language equivalents from the small chart in (b).
- d) Record your answers in the following:
Remember that if you drag down the corner of the C2 cell, it will automatically get $[H^+]$ for all your initial concentrations.

Initial Concentration (write this in A1 column)	K_A value (write this in B1 column)	[H⁺] (write this in C1 column)	pH (write this in D1 column)	% ionization (write this in E1 column)
0.5	4.30E-04			
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0.05	4.30E-04			
0.02	4.30E-04			
0.01	4.30E-04			
0.005	4.30E-04			
0.001	4.30E-04			
0.0005	4.30E-04			

- e) Write a formula for pH in cell D2, and then drag down the corner of the D2 cell. Finally recopy the values above. Remember to substitute $[H^+]$ in the pH formula with C2.
- f) Write a formula for % ionization in cell E2, and then drag down the corner of the E2 cell. Finally recopy the values above.
- g) Copy the values of column A, and paste them elsewhere.
- h) Copy the values of column E.
- i) Using the paste special command, and selecting "values only", paste them next to the pasted column from (g)
- j) Highlight both columns, click on the insert column, and select scatter.

k) Sketch the graph here and label both the axes.

l) What does the graph reveal about the relationship between initial concentration of $\text{HNO}_{2(aq)}$ and its % ionization?
