

**Exercise 3: A weak acid**

Given the reaction of an acid  $\text{HB} \rightleftharpoons \text{H}^+ + \text{B}^-$ , you want to determine the equilibrium constant (actually, the dissociation constant of an acid,  $K_a$ ). You will do this by observing the concentration of various species in a test tube.

1. Write the equilibrium constant expression for HB. Use  $K_a$  as the equilibrium constant. Use all or some of the following:  $[\text{H}^+]_{\text{equilibrium}}$ ,  $[\text{H}^+]_{\text{initial}}$ ,  $[\text{B}^-]_{\text{equilibrium}}$ ,  $[\text{B}^-]_{\text{initial}}$ ,  $[\text{HB}]_{\text{equilibrium}}$ ,  $[\text{HB}]_{\text{initial}}$ .
2. The HB flask has a concentration of  $2.5 \times 10^{-4}$  M written on the side. You pipet 10 mL into a test tube, then add 40 mL of 0.010 M sodium chloride. What is the concentration of the diluted HB? Hint: Is the concentration of the sodium chloride relevant?
3. Call this  $[\text{HB}]_{\text{initial}}$ . How come the original  $2.5 \times 10^{-4}$  M isn't called the "initial concentration"?
4. Suppose you measure the pH of the diluted solution (using a pH meter) as 7.66. What is the concentration of the hydrogen ion in the diluted solution? Is this the initial or the equilibrium concentration?
5. What must be the concentration of the  $\text{B}^-$  ion? Is this the initial or the equilibrium concentration? Why *must* it be this concentration?

6. What is the equilibrium concentration of HB? How do you calculate it from the answer to question 3?

7. Calculate  $K_a$ .

8. Suppose, instead of 0.010 M NaCl, to the original 10 mL of HB, 40 mL of 0.010 M HA (where HA is some generic weak acid) is added. Will the measured pH reflect only the protons dissociated from HB? Why or why not?

9. Given the scenario above, a pH of 6.67 is measured. Can  $K_a$  be calculated from the information given? If so, calculate it. If not, what other piece of information is needed?

10. Given the two scenarios (questions 7 and 9), should the  $K_a$ 's be different, since one scenario has HA and the other one doesn't? Explain your answer.