**PhET Tips for Teachers: *Acid-Base Solutions***

**Important modeling notes / simplifications:**

pH: You must dip the paper or the probe into the solution to measure pH. You can use this feature to allow students to *predict* the pH for different solutions. If you combine this sim with a lab, note that the pH of water (even distilled) usually comes out to about 5.5 rather than 7.0, because of dissolved carbon dioxide.

Conductivity: You must dip both electrodes into the solution to measure conductivity. The luminance of the bulb is modeled as linear with pH, and water is given a small conductivity. Note that the conductivity of distilled water will not be measurable with the equipment available to students. We chose not to allow the student to see the Views at the same time, since the sim only shows a static picture of the species in solution.

Concentration: The number of particles in the magnifying glass is related to the equilibrium concentration. We chose to ignore the autoionization of water for the acid and base solutions. Note the log scale on the bar graph.

First tab: Because the actual values are hidden in this tab, students can use the equilibrium concentrations to calculate the initial concentration of acid/base and Ka/Kb. The initial concentration is 0.01 M for all solutions and the equilibrium constant is 1e-7 for the weak acid/base.

Second tab: Note that you can keep all tests/views in the solution as you change the concentration/strength with the sliders. We elected to hide the K values in this tab, to enable students to focus on the *concept* of strength. The slider ranges from 1e-10 to 1e2 on a log scale.

**Insights into student use / thinking:**

Generic symbols: In an interview study (before instruction), we found that students are confused by the generic symbols for an acid and base – HA and B. You may want to give students some examples of real acids (such as HF and HCl) and introduce HA as a generic acid before you ask students to play with the sim.

Initial vs. equilibrium concentration: In the same study, we found that many students are not aware that the initial concentration of an acid/base is not the same as the equilibrium concentration – because of this confusion, some students think the strength slider controls the *progress* of the reaction. We added the words "initial" and "equilibrium" to the sim, but you may want to emphasize that acid/base solutions are in equilibrium.

Concentration vs. strength: In a classroom study, we found that students tend to think pH measures the *strength* of an acid/base. As a result, many students think a *stronger* weak acid means a more *concentrated* weak acid. We developed a sim activity to confront the student idea that concentration and strength are directly proportional.

**Suggestions for sim use:**

- For tips on using PhET sims with your students, see: **Guidelines for Inquiry Contributions** and **Using PhET Sims**.
- The simulations have been used successfully with homework, lectures, in-class activities, or lab activities. Use them for introduction to concepts, learning new concepts, reinforcement of concepts, as visual aids for interactive demonstrations, or with in-class clicker questions. To read more, see: **Teaching Physics using PhET Simulations**.
- For activities and lesson plans written by the PhET team and other teachers, see: **Teacher Ideas & Activities**.

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