

Macro and Micro screens

The **Macro** screen (*not shown*) targets qualitative concepts about the pH of everyday acids and bases, including dilution. The **Micro** screen (*below*) relates pH to H_3O^+ and OH^- ion concentrations:

SWITCH between concentration and moles

SWITCH between log and linear display

CHOOSE one of many everyday liquids

HIDE pH or concentration values and ask for student predictions

SHOW how many ions and water molecules.

Concentration (mol/L) | Quantity (mol)

off scale | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | 0

55 H_2O

1.6×10^{-8} H_3O^+ | 6.3×10^{-8} OH^-

Logarithmic | Linear

pH 5.80

Chicken Soup

Water

1 L | 0.60 L

5.69×10^{17}

2.26×10^{15}

1.97×10^{25}

$\text{H}_3\text{O}^+/\text{OH}^-$ ratio

Molecule count

pH Scale

My Solution screen

My Solution allows you to directly manipulate pH or ion concentration, instead of adding everyday solutions or water to the beaker:

DRAG H_3O^+ or OH^- sliders to customize pH. Changing one slider automatically changes the other.

ADJUST the pH directly. Press and hold to adjust quickly.

CHOOSE ratio view for a quick way to see the major ion in solution.

Concentration (mol/L) | Quantity (mol)

10² | 10⁰ | 10⁻² | 10⁻⁴ | 10⁻⁶ | 10⁻⁸ | 10⁻¹⁰ | 10⁻¹² | 10⁻¹⁴ | 10⁻¹⁶

55 H_2O

4.2×10^{-8} H_3O^+ | 2.4×10^{-7} OH^-

pH 7.38

1 L | 0.50 L

$\text{H}_3\text{O}^+/\text{OH}^-$ ratio

Molecule count

pH Scale

Model Simplifications

pH of everyday liquids

For liquids with a range of measured pH values, an average value from the literature was used.

Dilution

The simulation does not account for the different acid dissociation constants (K_a) for each liquid when calculating the ion concentrations or the pH after dilution. We make the simplification that any increase in the concentration of the major ion is due to the ions already present in the added water. *For example, if students add 100 mL of water to an acidic solution, then the number of moles of H_3O^+ increases by 1×10^{-8} mol.* The concentration of the minor ion is then calculated using the self-ionization constant for water (K_w). These calculations account for the leveling effect of water.

H_3O^+/OH^- ratio view

The ratios of ions have been simplified; the ion ratio varies logarithmically between pH 6-8, but is approximated as a linear relationship outside of this range.

Insights into Student Use

Because the **H_3O^+/OH^- ion ratio** is shown with dots, many students initially assume the dots represent the actual number of ions in the beaker. Asking students to display and discuss the molecule count at the same time can help. Also, since the ion ratio is approximated to a linear relationship at most pH values, the differences upon dilution or small changes in pH are difficult to see. Asking students to compare the ratio view across larger differences in pH elicits more interesting discussion and helps students interpret this view.

A sliding scale is used to show concentration and quantity values instead of a traditional bar **graph**, since the bar graph tended to cue students to compare the volumes of the bars. When shown a bar graph students tended to describe one concentration as twice as large as another, when the values were actually many orders of magnitude different.

From having used indicators like litmus paper or pH paper, some students may think that the **color of the substance** is related to pH; to address this idea, the My Solution screen shows a solution that does not vary in color. Also, battery acid and drain cleaner have purposefully identical colors.

Sample Challenge Prompts for Students

- Predict if the pH of your solution will increase or decrease after you add water. What about the concentration of H_3O^+ ions?
- Describe two different ways you could fill the beaker with a solution with pH 6.00. Is it possible to use hand soap to do this? Explain.
- Given only the solution pH, how would you estimate the concentration of H_3O^+ ions in a solution? What about the concentration of OH^- ions?

See all published activities for pH scale [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).