pH of Common Household Liquids – High School (Grades 9+)

Introduction to pH and Determining pH Values

OBJECTIVE:

• Introducing the concept of pH and the definition of pH – ""A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing above 7 with increasing alkalinity and decreasing below 7 with increasing acidity. The pH scale commonly in use ranges from 0 to 14." Certain chemical compounds release H+ (hydrogen ions) when they are in water and others release OH – (hydroxide ions). The pH of a solution is the measurement of the H+ or OH – present in solution. Acids release H+ in water and bases release OH – in water. The normal pH scale ranges from 0-14 and was designed to measure the acid or base content present in common chemical solutions.

pH is the p (potential or power of) H (Hydrogen); the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per liter. The pH scale is a logarithmic scale. This means that a substance at pH 6 is ten times more acidic than a substance at pH 7. The logarithm of pH is represented below: pH = -log (hydrogen ion concentration) = -log [H+] Using a scientific calculator students can work with logarithms.

• Example: What is the concentration of the hydrogen ion concentration in an aqueous solution with pH = 13.22?

pH = -log [H+] = 13.22
log [H+] = -13.22
[H+] = inv log (-13.22)
[H+] = 6.0 x 10-14 M (2 sig. fig.)

• Introducing the pH scale of 0-14 and how a solution is placed on this scale according to its pH value – students can also draw their own pH scales to help understand how to plot known values.

• Introducing the idea of a hypothesis. Students will "guess" what they think the pH value may be of a known liquid. Students can try to hypothesize what the pH range may be instead of just stating "acidic" or "basic". Have them write down a number.

MATERIALS:

• Known liquids they could make a hypothesis about: examples include, milk, tap water, Coca Cola®, lemon juice, pineapple juice, orange juice, etc.

• Known liquids that they are required to be CAREFUL with and DO NOT taste: examples include vinegar, soapy water, liquid drain cleaner, bleach, Milk of Magnesia, baking soda water, etc. Note – use proper caution when handling some of the above solutions, not appropriate for younger students to handle and remind them to NEVER taste a solution to estimate its pH

• EcoSense® pH10 or pH100 instrument (www.ysiecosense.com). pH10 instrument shown at right.

- Calibration solution for instrument

- Paper towels

- Safety glasses or gloves for older students allowed to handle non-consumable liquids along with proper ventilation if using bleach

- pH Data Table to record values

- Clean water or sink to rinse pH instrument electrode

PROCEDURE:

- Calibrate the pH instrument with the calibration solutions (pH buffers 4, 7, and 10). The teacher can complete this process easily or the students can assist. This allows students to use a scientific instrument and understand the process of acquiring scientific data. Students can also calibrate and record the calibration values for each buffer.

- Pick a liquid and discuss it briefly. What assumptions can students make about its acidity level based on taste or known uses of the solution? Have them make a guess and write it on their Data Table. Let them know that 7 on the pH scale is neutral and values below 7 are acidic while values above 7 are basic (not acidic).

- Complete the above step for all liquids.

- Once the students have placed their guesses on their data table start measuring each liquid and be sure to rinse and shake the electrode between solutions. Have them record the actual values on their Data Table next to their guesses.

- Next to each value on their Data Table have them determine if the solution is acidic, basic, or neutral. Students can determine if the solution is "slightly", "moderately", or "very" acidic or basic. Have the students determine if their definition means the solution has more Hydrogen (H+) or Hydroxide (OH-) ions. Remember, acid solutions have more hydrogen ions and basic solutions more hydroxide ions. Also have the students determine the hydrogen ion concentration using the logarithmic functions on their scientific calculators.

- After testing all solutions, place the pH instrument electrode back into the pH 4, 7 and 10 buffer solutions as part of a post-calibration check. Record the numbers. See how closely the pH values of the post-check come to the recorded values of the calibration. This teaches students to check their data and understand how accurately the values of their test are.

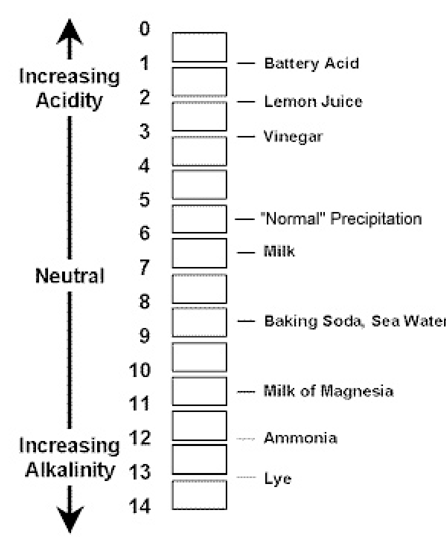
Additional –

Have the students make hypotheses about what will happen if two substances of varying pHs are mixed together?

Does the pH just average out in a 50/50 mixture or does it stay closer to the more acidic value? This is OK for students to do with consumable liquids – if older students are doing this with non-consumable liquids ALWAYS slowly pour the more acidic solution into the less acidic solution to prevent splashing of the acidic solution.

Have the students add tap water to a solution to see how it affects the overall pH since it will be relatively neutral.

Have students make a pH scale similar to the one shown with the solutions used:



Example Data Table for students to fill in:

Solution	Estimated pH	Actual pH	Acid, Base, Neutral	More H+ or OH- ions?	Hydrogen Ion Concentration

Thought Provokers:

How accurate were the estimations?

Can you closely determine the pH of a solution?
Note: Remind students to NEVER taste a solution to try to determine its pH value

Which substance is the strongest acid, base?

If a substance has a pH of 3 which of your solutions would you use to bring the pH up to 7?

How do you think different pH ranges could affect fish or other aquatic life?

Do you think different pH values could be dangerous to people? How?

Do you think the pH in your stomach is acidic or basic? Why? (Stomach pH is approximately 2 to help break down and digest food)

What is the pH of an aqueous solution in which [H+] = 2.7 x 10-3 M?