

Mentoring Advanced Placement Biology



Topic: Photosynthesis, atmospheric gasses

Quick Question: pH is defined as equal to $-\text{Log} [\text{H}^+]$, where $[\text{H}^+]$ is the concentration of hydrogen ions in the aqueous solution being measured. Pure water is naturally at $\text{pH}=7$, and as pure rain forms it is also at $\text{pH}=7$.

Q: If rain drops begin at $\text{pH}=7$ and fall through unpolluted air what will the pH be at ground level?

Challenge Activity:

- Design an experiment testing the atmospheric change brought about by a living plant.
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QQ Solution: As droplets move through the atmosphere, CO_2 gas dissolves into the water. In solution with water, CO_2 reacts to form H_2CO_3 , carbonic acid. This rise in acid, and increase in acidic H^+ ions, lowers the raindrop pH. So, rain in clean air has an average pH of about 5.6, and is not considered "acid rain" until the pH is below 5.

Overall, carbonic acid is relatively weak. More rapidly visible acid rain issues arise with the presence of sulfur or nitrogen containing compounds, often coming from industrial exhausts. These compounds combine with water and oxygen in the atmosphere to form potent nitric and sulfuric acids.

Challenge Solution and Discussion:

Sometimes it's fun to go back and test the basics. The process elucidates foundational aspects of science, and shows the way to modern extensions.

In the 1700's when scientists were attempting to unravel the basics of life forms they started to experiment with plants, testing rhythms of blooming, sense for gravity, sense for light, and how plants gained mass. They also tested life-giving qualities effused by plants.

In one major experiment of 1771, Joseph Priestley showed that plants give off oxygen gas, though he didn't know for certain what the gas was at the time.

Here is his experiment. Feel free to use this method, or one brought forward by the group if it seems more interesting.

Supplies

- large glass jar, glass container, with tight sealing lid
- small candle
- small plant, with soil, that fits inside jar.
- Large magnifying glass
- Flood light/halogen desk light

1. Place the plant and candle under the jar and screw the lid on tightly. Place a layer of tape or sealant around the lid's seam if its seal is uncertain.
2. Using the magnifying glass and flood lamp, (strong light source), light the candle. This may be excessively tricky if the jar has sides which make the light diffuse.
3. Let the candle burn until it uses all available oxygen and extinguishes. Place the jar on a well lit window sill, and wait for one week.
4. Upon returning, use the magnifying glass to relight the candle and show that an atmospheric change has taken place. (Condensation may complicate relighting, try to avoid this by using a plant with soil that is damp and not excessively wet.)

Oxygen is not the only combustible gas. Try to form an argument that the replenished gas is oxygen. What would the flame look like if the new gas was concentrated hydrogen?