KILROY ACADEMY

NAME: _____ DATE: _____

LOGARITHMS AND THE pH SCALE

- **A scientific application of Logarithms is the pH scale which is used to measure the concentration of H^+ ions in an acidic or basic solution.**
- **pH is equal to the negative logarithm of the hydrogen concentration in a solution. The equation is pH= -log[H^+] where [H^+] represents the hydrogen concentration in a given solution.**
- **It turns out the hydrogen concentration can vary from 1 molar to 1 x 10^{-14} molar in a solution. Fourteen orders of magnitude would be difficult to graph with a standard scale. A logarithmic scale is suited perfectly for this range in values.**
- **Since the concentration varies from 1 to extremely small values, we take the negative log in order to always have a positive value of pH. The video teaches is that pH values range from 0 to 14, with 0 being the most acidic and 14 being the least acidic or the most basic.**

Using the above information and insights learned from *A Marine Scientist's Guide to Logarithms* complete the following questions.

1. Complete the following table filling in the pH values.

Substance	$[H^+]$	pH
Battery acid	1×10^{-0}	
Hydrochloric acid secreted by stomach lining	1×10^{-1}	
Lemon juice	1×10^{-2}	
Orange juice, soda	1×10^{-3}	
Tomatoes; acid rain	1×10^{-4}	
Coffee	1×10^{-5}	
Saliva	1×10^{-6}	
Pure water	1×10^{-7}	
Sea water	1×10^{-8}	
Baking soda	1×10^{-9}	
Milk of Magnesia; Great Salt Lake	1×10^{-10}	
Ammonia solution	1×10^{-11}	
Soapy water	1×10^{-12}	
Lye – Sodium hydroxide; bleach	1×10^{-13}	
Drain cleaner	1×10^{-14}	

2. What does a change from a pH of 2 to a pH of 3 mean in terms of the concentration of H^+ ions?

3. How many times more concentrated is an acid with a pH of 4 compared to a pH of 6?

- **Sometimes we would like to determine the concentration when we have the pH of a solution. This requires what is called the antilog.**

  The equation is $[H^+] = 10^{-pH}$

  Thus if we have a pH of 3, the concentration is 1×10^{-3}

4. White vinegar has a pH of 2.4 while apple cider has a pH of about 4.25. What is the difference between these two types of vinegar in terms of $[H^+]$?

5. Human blood has a normal pH range of 7.35 to 7.45. The range seems fairly small in terms of pH but what is the range in terms of $[H^+]$.

6. Hypothesize as to how a person's blood pH level might be increased to a level greater than the acceptable range.

7. The average pH of ocean surface waters has fallen by about 0.1 units, from 8.2 to 8.1, since the beginning of the industrial revolution. What is the percent increase in acidity?

8. Gases are more soluble in cold water. Which ocean waters do you think have the highest acidification?

- **Economically valuable molluscs such as mussels and oysters are highly sensitive to ocean acidification, as the aragonite saturation (calcium**

carbonate) is reduced at lower pH. Already, some shellfisheries have had to adapt to lower pH levels or relocate.

9. What would the pH of shellfishery be if the $[H+]= 1 \times 10^{-5}$?

10. Would you expect molluscs to be put in stress at this pH?

- **Most studies demonstrate that calcification – the ability for some organisms to produce shells or skeletons – decreases with ocean acidification. These include planktonic calcifiers (such as foraminifera, coccolithophorids and pteropods), corals and molluscs, as well as echinoderms (e.g., urchins) and less so crustaceans (e.g., crabs). An analysis of ocean acidification studies shows that many calcifying organisms also show a decrease in survival, growth, development and abundance. In many calcifying groups, early life stages are most sensitive to CO_2-induced changes in seawater chemistry. Crustaceans are less affected than corals, molluscs or echinoderms. Early life stages of many molluscs (larvae and juveniles) as well as adults have shown reduced calcification, growth and survival. This makes molluscs one of the groups most sensitive to ocean acidification.**

11. Would you describe the relationship between acidification and calcification to be direct or inverse?

12. If we were to graph the pH of the water vs. the calcification ability what would the graph look like?

13. Explain how the acidification of the world's oceans has a direct impact on you or your family?

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