CLASSWORK – OCEAN ACIDIFICATION – AP ENVIRONMENTAL SCIENCE

Name: **Period:**   **Date:**

1. **Background Information**: **Briefly review your notes on climate change and ocean acidification.**

What is ocean acidification?[1]

Rising atmospheric CO_2 levels are not only increasing global temperatures, but as the ocean absorbs more of this CO_2 it is changing the chemistry of the seawater, a process called ocean acidification (OA). International experts define ocean acidification as a decrease in ocean pH over decades or more that is caused primarily by uptake of CO_2 from the atmosphere.

Because modern human activities (especially burning of fossil fuels) release more CO_2 into the atmosphere, the ocean is taking up CO_2 faster today than it has in the past. As carbon dioxide dissolves into seawater, it creates carbonic acid. Through a series of chemical reactions, carbonic acid releases hydrogen ions - which decreases seawater pH, and decreases the concentration of carbonate ions - which provide chemical building blocks for marine organisms' shells and skeletons.

Many marine organisms are very sensitive to either direct or indirect effects of the change in acidity (H+ concentration) in the marine environment. Physiological processes such as respiration, calcification (shell/skeleton building), photosynthesis, and reproduction are affected by changes in CO_2 concentrations in seawater - along with the resultant changes in pH and carbonate ion concentrations - that are expected over the next century.
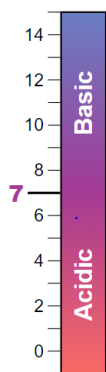
2. **Make sure you understand the pH scale. If you do not remember how the pH scale works, use this link[2] to view a simulation.**

"Acidity" is the concentration of hydrogen ions (H+) in a liquid, and pH is the scale on which this concentration is generally measured. The amount of hydrogen ions in a liquid determines how acidic the liquid is.

3. **Look up ocean pH values using at least 3 worldwide ocean buoys** (floating devices that are anchored in the ocean and used for science or navigation). Create a simple table from the data resources below and show the name of the buoy, the general location, date, and pH value.

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[1] Adapted from Cooley, S., Mathis, J., Yates, K, and Turley, C. eds. Frequently Asked Questions about Ocean Acidification. U.S. Ocean Carbon and Biogeochemistry Program and the UK Ocean Acidification Research Programme. Version 2. 24 September 2012. www.whoi.edu/OCB-OA/FAQs
[2]PhET Interactive Simulations. University of Colorado, Boulder, 2015. https://phet.colorado.edu/sims/html/ph-scale-basics/latest/ph-scale-basics_en.html.

Name of Buoy	General Location	Date of Reading	pH value

Data Resources:

- NOAA Data Portal: https://www.pmel.noaa.gov/co2/map/index
- Mooring Data Viewer: https://www.nodc.noaa.gov/oads/stewardship/mooring_table.html

4. **Analyze pH measurements taken from an oceanic research cruise in the Gulf of Mexico.**

   a) *Browse.* Take 5 minutes to browse the information on the NOAA (National Oceanic & Atmospheric Administration) ocean science cruise from 2012 (GOMECC-2). This is a good example of scientists (and college students!) doing research. You might choose to watch the video or read a blog.

   b) *Download data.* Click CRUISE DATA ☐ DISCREET SURFACE SAMPLES. Download the Excel file of measurements directly taken from seawater samples while the ship was underway conducting research.

   c) *Locate and highlight the column on pH readings taken from ocean water samples.*

   pH_TOT

   8.0992
   8.0961
   8.0986
   8.1107
   8.1012

   d) *Calculate the mean and median for pH readings* taken on this cruise from surface water samples. Measures of <u>central tendency</u>—mean, median, and mode—can help you capture, with a single number, what is typical of a data set.
      - The <u>*mean*</u> is the average value of all the data in the set.
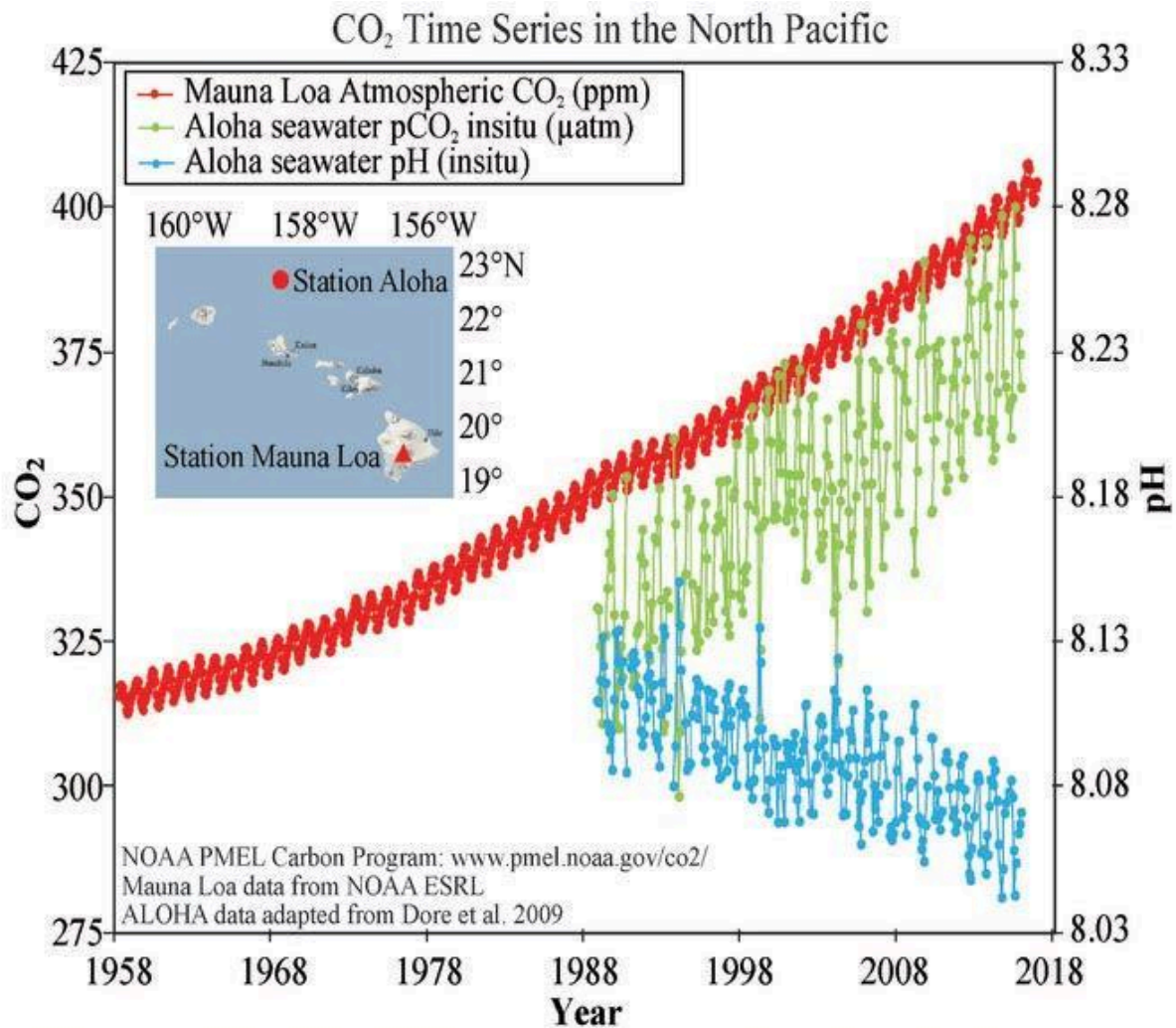
        Average = _____
      - The <u>*median*</u> is the middle value in a data set that has been arranged in numerical order so that exactly half the data is above the median and half is below it.

        Median = _____

   e) *Graph the data set.* Highlight the pH values in the column, and then select the INSERT LINE from the graphing function in Excel. Label your graph. How much did the pH change in August Gulf of Mexico readings? Is the data what you expected? Why or why not?

5. **Analyze the long-term graph below and answer the following questions.**[3]

CO₂ Time Series in the North Pacific

Legend:
- Mauna Loa Atmospheric CO_2 (ppm)
- Aloha seawater pCO_2 insitu (µatm)
- Aloha seawater pH (insitu)

NOAA PMEL Carbon Program: www.pmel.noaa.gov/co2/
Mauna Loa data from NOAA ESRL
ALOHA data adapted from Dore et al. 2009

Data: Mauna Loa (ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt) ALOHA (http://hahana.soest.hawaii.edu/hot/products/HOT_surface_CO2.txt)
Ref: J.E. Dore et al, 2009. Physical and biogeochemical modulation of ocean acidification in the central North Pacific. *Proc Natl Acad Sci USA* 106:12235-12240.

6. **Name the 3 variables being measured.**

7. **Are CO_2 concentrations fluctuating (changing) each year, or are they the same each year?**

8. **Regardless of fluctuations each year, this graph clearly shows the overall _longer-term_ trend of each of the 3 variables being measured. What are the overall trends for CO_2 (atmosphere), CO_2**

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[3] Image: NOAA, PMEL Carbon Program https://www.pmel.noaa.gov/co2/file/Hawaii+Carbon+Dioxide+Time-Series

(dissolved in seawater), and pH (of seawater) – are they increasing, decreasing, or staying about the same?

CO_2 (atmospheric) trend	
CO_2 in situ (dissolved in seawater) trend	
pH (seawater) trend	

9. **Briefly describe, in your own words, how atmospheric CO_2 and ocean pH levels are related. Be specific.**

10. **When taking measurements of CO_2 and pH, what natural (not anthropogenic) factors might influence data readings over smaller periods of time such as month-to-month, different seasons, and different geographical locations on the Earth? For example, why might ocean pH values be different at different times of year in the same area of the Gulf of Mexico?**

11. **There are both natural and anthropogenic (man-made) sources of CO_2 being added to the atmosphere. The largest source of anthropogenic CO_2 comes from burning fossil fuels. Many states have renewable energy goals to switch energy production away from fossil fuels. <u>Make a claim and predict</u> what will happen to ocean pH if the U.S. produces 50% of its energy from renewable energy (not fossil fuel) sources by 2050. Use <u>evidence and reasoning</u> to support your answer.** Use last sheet of paper if additional space is needed.

- CLAIM that ocean pH will . . .

- EVIDENCE from data that support my claim are . . .

- REASONING that my claim is valid is because ("how" this works – *use one external source of information to support your reasoning and cite your source*).

12. **Environmental Impacts. Read the [NOAA discussion](#) on environmental impacts from ocean acidification and describe, in your own words, one current environmental impact that will likely get worse over time if CO$_2$ concentrations continue to rise globally. You might choose to discuss impacts on pteropods, shellfish, or coral.**