Science-1A Lecture: Week-14, Monday, November 8, 2021

Effect of Increasing Atmospheric CO_2 on the Oceans

This online teaching is tough. I want to show you a handout about how our CO_2 emissions affect the pH of the oceans, but as I looked over that handout I was afraid that it might put you to sleep without your teacher prancing around in front of the classroom, providing emphasis, background information, and stories to bring it alive. Sorry, that cannot happen, but here is a bit of context, the link to that handout, and a video to watch.

When we watched the animation of evaporation at
https://yosemitefoothills.com/Science-1A/Handouts/Week-04/EvaporationIntoVacuum-40K.gif ,
I stressed that this is a model for all of chemistry. It shows how a chemical process proceeds until a steady state equilibrium condition is achieved. That equilibrium depends on the surrounding thermodynamic conditions. In the evaporation case, temperature kicks molecules out of the liquid into the gas and gas pressure builds until gas molecules return to the liquid at a matching rate. After a while, the rate of ejection becomes matched by the rate of return.

In a more recent note, I mentioned how salt crystals dissolve in water until there are enough ions in the water that elsewhere in the solution ions meet and form new crystals. Eventually, the rate of dissolution matches the rate of creation and a steady state equilibrium condition is achieved.

When we did our electrolysis of water to make hydrogen and oxygen, there was no equilibrium. The hydrogen and oxygen molecules did not have enough thermal energy at room temperature to recombine until a spark was added. The gas creation continued until the applied electrical current was stopped. Then with the spark, the reaction happened irreversibly in an explosion. Under suitable conditions of gas pressure and temperature, the reaction can be made to achieve an equilibrium without an explosion as is done in a hydrogen fuel cell where the reaction can be guided in whichever direction is desired. Our discussions of burning hydrocarbons to produce energy is similar; under normal conditions it seems to only go one way. Going backwards is much more complicated; plants do it using sunlight energy and much more complicated chemistry.

Now to the point of this note. The ocean is full of reactions that are nearly in equilibrium, they go either way depending on the relative concentrations of the reactants (left side stuff) and products (right side stuff). If there are lots of reactants and few products, the reactions make more products and we might just use a "=>" symbol to show that. If on the other hand, there are few reactants and an abundance of products, the reaction will go the other way and we might use the symbol "<=". In truth all reactions can go either way and the appropriate symbol is "<=>".

Not only that, there are often many reactions simultaneously operating in a solution, all of which are changing the concentrations of the component molecules. Things get quite complicated. That is how it is in the ocean.

Now, with this in mind, I hope you can better understand the handout entitled "Carbon Dioxide, Water, Oxygen and Life" at
https://yosemitefoothills.com/Science-1A/Handouts/Week-10/CO2WaterAndLife.pdf .

Also, to better understand ongoing research into this problem, watch the short TEDx talk entitled "Ocean acidification - the evil twin of climate change" presented by Triona McGrath in Dublin, Ireland. It is at
https://www.youtube.com/watch?v=8m1X26Auw6Q .

The lecture by Triona McGrath presented an informative graphic showing data up to 2007. A similar figure that extends to 2021 is at
https://yosemitefoothills.com/Science-1A/Chapter_11-WaterAndSolutions/co2_time_series_aloha_11-16-2019_v5.jpg .

These data show how decade after decade atmospheric CO_2 is steadily increasing, and the ocean is steadily becoming more acidic.