HW3

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In this assignment you will be reviewing key Redox and nutrient ideas from class The goal of this is to get you thinking about how chemistry controls many aspects of water quality and how we can use that knowledge to improve water quality.

For all analytical responses show your work, this can be hand-written (your handwriting should be clear), typed up, or if you want to code it up in Rmarkdown and turn in a knitted html, I'd love that!

1. What are some at least 3 key nutrients for life? Name one nutrient cycle that people have radically altered.
2. Redox reactions (reduction-oxidation reactions) are the reactions that power much of life's functions. In a redox reaction what is being exchanged between elements and molecules that generates energy?
3. What are two redox dependent reactions that can control nutrient concentrations in freshwaters? Why are these reactions redox dependent?
4. Oxidation number is an important concept for tracking where electrons are in a chemical reaction. What is the oxidation number for each element in the following chemical equations? You should give just the oxidation number per element for example for Fe_2O_3 the answer would be `O=-2, Fe = +3`.

- Acetate - CH_3COO^-
- Sulfate - SO_4^{2-}
- Hyrdrogen ion - H^+
- Carbon Dioxide - CO_2
- Hydrogen Sulfide - H_2S
- Water - H_2O

5. Acetate can be used as an energy source for microbes in an oxic environment with the equation:

   $CH_3COOH + 2O_2 - > 2CO_2 + H_2O$

   where acetate is oxidized by O_2 as the final electron acceptor. Note the terminology is confusing `oxidizing` a substance means that that substance is `reduced`. Oxidizing is the act of taking electrons of a substance, thereby reducing it. For this reaction, we can calculate the total Gibbs free energy relased using the equation:

   $G^°= $\sum \Delta G_{products} - \sum \Delta G_{reactants}$

   The standard gibbs free energy (ΔG_f°) for each component in the reaction is:

   $CH_3COO^- =$ - 396.46

   $O_2 = 0$

   $CO_2 =$ -385.98

   $H_2O =$ -237.18

   What is the G$^\circ$ for the entire reaction? (Remember to multiply ΔG values by the # of moles of each reactant and product)

6. What is the difference in standard free energy yields for these three reactions?

   $CH_3COOH + 2O_2 - > 2CO_2 + H_2O$

   $CH_3COOH + 2SO_4^{2-} + 2H^+ - > 2CO_2 + H_2S + 2H_2O$

$CH_3COOH + 2NO_3^- + 2H^+ -> 2CO_2 + N_2 + 4H_2O$

Additional standard gibbs values you will need

SO_4^{2-} = -744.53

H^+ = 0

H_2S = -27.83

NO_3^- = -108.74

N_2 = 0

7. Rank the final electron acceptors from the above equations in order of most gibbs free energy yield to least (use oxidation numbers to figure out which reactant loses and receives electrons)?