

ESSC113/C213: Biological and Environmental Geochemistry

Final Exam (short practice version)

You will have a total of two hours and forty-five minutes to complete this exam. One you start the exam, please work continuously through each part until it is completed. Once Part One is completed, please turn it in before beginning the 2nd part; do not go back and modify or add to it. You may use as much of the time limit on each part as you wish.

Part one is closed book (you only need a pencil/pen), and is worth 1/3 of the total points.

Part two is open book/open note (textbook, notes and handouts are ok, and you can type your responses if you want, but please do not use the internet, email, or any other communication device for any purpose other than as a calculator). It is worth 2/3 of the total points.

Sketches and diagrams are encouraged. Remember to label axes and include scale bars where appropriate!

NAME: _____

Part 1 (2 pages): Closed book – Please complete and set aside before starting part 2.

1. What are the two main nutrients controlling the rate of photosynthesis in land plants?
2 pts.
2. Write a simple chemical equation for photosynthesis. 1 pt.
3. Rank the following elements/ions in order of increasing tendency to leach away during soil formation in the Belbex basalts. 2 pts.
Si⁴⁺ ___
Al³⁺ ___
Na⁺ ___
Ti⁴⁺ ___
4. Why is soil water typically roughly neutral in pH, while rainwater is typically slightly acidic? (2pts)
5. Rank the following in order of increasing $\delta^{13}\text{C}$ (or $^{13}\text{C}/^{12}\text{C}$). 2 pts.
___ Atmospheric CO₂
___ Limestone (CaCO₃)
___ Plants
6. Describe changes in the atmospheric abundance of CO₂, on both seasonal and decadal time scales. (2pts)
7. Astronomers have described the Earth as a “carbon desert”, because of the low abundance of this element relative to, for instance, silicon at the surface of our planet. Why might the Earth have a lower carbon/silicon ratio than the sun? 2pts.

NAME: _____

Part II (3 pages): Answer 2 of the following questions (not all of them!). Open notes/open book. Diagrams/sketches/graphs are encouraged, make sure to show equations and algebra when appropriate. 10 pts/question. If more than 2 are answered, the mean score will be used.

1. Compare and contrast time scales of mixing in the troposphere, stratosphere, and ocean. What processes control the mixing and/or density stratification in each reservoir?

2. It is observed that the $\delta^{13}\text{C}$ of limestones (CaCO_3 deposits in the crust) varies inversely with the $\delta^{34}\text{S}$ of sulfate minerals on geological (> 10 Myr) time scales. Why might this occur? Do you expect a strong inverse correlation at shorter time scales? Why or why not?

3. Arsenic can occur in toxic concentrations in groundwater used for drinking – this is a major problem in Bangladesh, for instance. The mobilization of arsenic appears to be strongly tied to microbial respiration of arsenate (H_2AsO_4^- at a pH of 6) to arsenite (H_3AsO_3 at the same pH). $pe^0 \approx +11$ for the reaction:



What is the oxidation state of arsenic in a) arsenate and b) arsenite?

Calculate the pe of this reaction at $\text{pH} = 6$ (show your work!), assuming 1 mol/liter concentration of arsenate and arsenite (they're not nearly this common in real groundwater, but let's keep it simple for the purposes of the exam).

Is this reaction more oxidizing, or reducing, than sulfate reduction?

If an organism could choose either reaction to respire organic carbon, which would yield the most energy?