

Provide answers in the space below each question. This is a take-home, open book exam. You are expected to work alone and seek information only from published sources. It is recommended that you work the solutions on a “sloppy copy” and then neatly transfer your response to the exam copy. Show **all** your work on the exam copy and please do not report anything beyond 3 significant figures.

1. Write a balanced hydrolysis/oxidation reaction of biotite, carbonic acid, water, and oxygen to form hematite, kaolinite, bicarbonate, dissolved species and ions. Assume biotite octahedral stoichiometry is  $(\text{FeMg}_2)$ .
2. Calculate the surface area ( $\text{km}^2$ ) of the Earth.
3. Assuming 30% land coverage and an average rate of upper continental crust erosion of 1 m per  $10^6$  years, what is the volume of mass ( $\text{m}^3$ ) loss to the oceans each  $10^6$  years
4. Using oxide formula weights, calculate the formula weight of biotite (include units!). Assuming biotite has a density of  $3 \text{ g/cm}^3$ , then what is the volume of one mole of biotite?
5. Assume the continental upper crust is 20% by volume igneous and metamorphic rock. Also assume 4% of continental upper crust igneous and metamorphic rock is by volume biotite. How many moles of biotite are weathered each  $10^6$  years?
6. Our atmosphere currently has  $3.8 \times 10^{19}$  moles of  $\text{O}_2$ . If photosynthesis were to stop immediately and biotite oxidation (see rate in question #5) were the sole source of oxygen consumption (see also question #1 above), then how many years would it take to deplete the Earth's  $\text{O}_2$ ?

7. What is the effect of photosynthesis on the  $\delta^{13}\text{C}$  content of the biosphere compared to the  $\delta^{13}\text{C}$  content of the atmosphere?

8. You're in charge of water quality control. Three samples have been tested for Eh and pH. You spilled your B-horizon mud slurry on the paperwork. You need to tell the new head of the GA EPD results in 20 minutes and the only thing you can read on the paperwork is that sample **A** came from a pyrite acid mine drainage pond at Graves Mountain, GA, sample **B** came from a 50 ft. deep bore hole in Athens, GA, and sample **C** came from a stagnant salt marsh near Jekyll Is., GA. Match the data with samples.

- 1<sup>st</sup> result: pH = 7.7, Eh = 225 mV
- 2<sup>nd</sup> result: pH = 2.2, Eh = 421 mV
- 3<sup>rd</sup> result: pH = 7.6, Eh = -249 mV

9. Use the mercury cycle figure below to determine the following.

- a. Residence time of Hg in the atmosphere, land, oceans, and sediments
- b. If we were to mine Hg from sediment and leak it to the land surface, how would the vapor and river fluxes vary assuming zero<sup>th</sup>, first, and second order models?

