

EAS1600 - INTRODUCTION TO ENVIRONMENTAL SCIENCES

Fall, 2014

Exam 4 – 11/24/14

- < **Answer all questions**
- < **Show all your work and be sure and report units where appropriate**
- < **Place your name on each page**
- < **This is a closed-book exam; all are expected to comply with Georgia Tech Honor Code**

I am aware and in compliance with the Georgia Tech Honor Code and I agree to abide by the grading policies of this class.

Signature: _____

Print Name: _____

Lab Section: _____

B

Answer the following multiple choice questions (1 – 5) by circling the best answer.

1. The Hawaiian Islands were formed by what process?

(5 points)

- a) ocean-ocean plate convergence
- b) The pacific plate passing over a hot spot**
- c) ocean-ocean plate divergence
- d) ocean-continent plate convergence

2. What type of rock below is metamorphic?

(5 points)

- a) granite
- b) limestone
- c) basalt
- d) marble**

3. Which of the following pieces of evidence did Wegener use to promote his theory of Continental Drift? Circle all that apply

(5 points)

- a) Evidence of previous glaciers in regions that are currently warm.**
- b) The similarity of fossils across continents.**
- c) The close fit of the coast lines of South America and Africa**
- d) The magnetic striping of rocks on the bottom of the ocean

4. Which of the following minerals would you expect to weather the most rapidly?

(5 points)

- a) Calcite
- b) Halite**
- c) Quartz
- d) Olivine

5. Which of the following is formed due to Ocean-Ocean plate convergence? Circle all that apply.

(5 points)

- a) The Himalayas
- b) Hawaiian Islands
- c) Aleutian Islands**
- d) The Andes Mountains

6. For the following compounds state the oxidation number of the C and also state if the compound is organic or inorganic. (10 pts)

<u>Compound</u>	<u>Oxidation#</u>	<u>Organic/Inorganic</u>
CH ₃ COOH	<u>0</u>	<u>O</u>
C ₁₂ H ₂₄ O ₁₂	<u>0</u>	<u>O</u>
HCO ₃ ⁻	<u>+4</u>	<u>I</u>
CO ₂	<u>+4</u>	<u>I</u>
C ₈ H ₈	<u>-1</u>	<u>O</u>

7. True or False. Mark each statement below as True or False (2 pts each)

- The location of an earthquake epicenter can be determined by using 2 seismographs. F
- The Himalaya Mountains are not volcanic. T
- The pH of the rainwater is effectively buffered by CO₂ dissolving from the atmosphere. F
- India and Australia are on different tectonic plates. F
- As atmospheric CO₂ increases, rock weathering is more rapid. T
- Iceland is situated above a hot spot and is also divided by the mid-Atlantic ridge. T
- The Aleutian Islands are formed due to hot spots. F
- Stone Mountain is made out of basalt. F
- Hawaii is made out of granite. F
- The pH of the ocean is neutral. F
- Basaltic lava flows can travel large distance as they are very fluid. T
- The pH of rain even in unpolluted environments is acidic. T

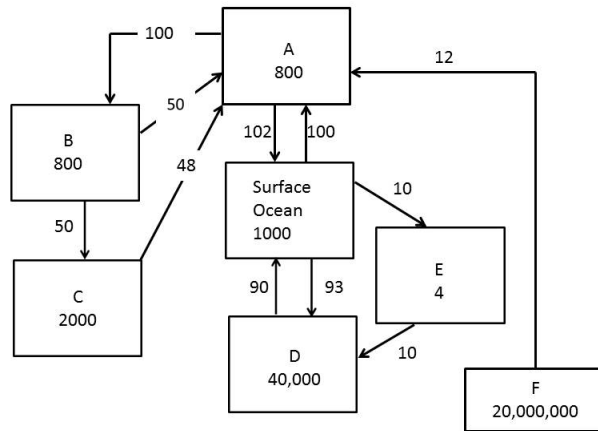
8. A seismograph records an earthquake with an epicenter that is at a distance of 1000 km. The difference in arrival times of the S and P waves are 60 s. assuming the S wave travels at 4 km/s what is the P wave velocity? (6 pts)

$$t_p = \frac{D}{v_p}, t_s = \frac{D}{v_s}$$

$$\Delta t = t_s - t_p = \frac{D}{v_s} - \frac{D}{v_p} = D\left(\frac{1}{v_s} - \frac{1}{v_p}\right)$$

$$v_p = \frac{1}{\frac{1}{v_s} - \frac{\Delta t}{D}} = \frac{1}{\frac{1}{4 \text{ km/s}} - \frac{60s}{1000 \text{ km}}} = 5.26 \text{ km/s}$$

9. Answer the following questions about Earth's short term Carbon Cycle (i.e. a time scale of decades to centuries) based on the diagram below. All reservoir amounts are in Gtons of C and all fluxes (arrows) are in Gtons/yr. (20 pts)



- Identify the reservoirs labeled A, E, and F.
A: Atmosphere; E: Ocean biosphere; F: Organic sediments/fossil fuels
- What is the residence time of carbon in the Living Land Biosphere?
 $t = 800/100 = 8 \text{ yr}$
- Identify two reservoirs that are composed of primarily organic carbon.
B: Living land biosphere,
C: dead land biosphere
E: ocean biosphere
F: organic sediments
- Write out a chemical reaction that removes carbon from the atmosphere.
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_2\text{O} + \text{O}_2$,
Or $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$, and $\text{CaCO}_3 + \text{H}_2\text{CO}_3 \rightarrow \text{Ca}^{2+} + 2\text{HCO}_3^-$
- Identify two reservoirs that are composed of primarily inorganic carbon.
A (atmosphere), Surface ocean, and D (deep ocean).

- f) What is the process that connects the ocean biosphere to the deep ocean?
Decay/respiration/Biological pump/death/sinking

10. Calculate the pH of the aqueous solutions below. (15 pts).

- a) Estimate the pH of a rain if there is enough CO₂ in the atmosphere to produce 1.6 x 10⁻⁵ mole/l of carbonic acid (H₂CO₃) in aqueous solution. (5 pts)

H ₂ CO ₃	↔	H ⁺	+	HCO ₃ ⁻
1.6 x 10 ⁻⁵		0		0
-x		x		x
1.6 x 10 ⁻⁵ -x		x		x

$$\frac{[H^+][HCO_3^-]}{[H_2CO_3]} = K_a$$

$$\frac{x^2}{1.6 \times 10^{-5} - x} = 4 \times 10^{-7}$$

Assume x is much smaller than 1.6 x 10⁻⁵, $\frac{x^2}{1.6 \times 10^{-5}} = 4 \times 10^{-7}$
 $x = 2.53 \times 10^{-6}$

pH = -log[H⁺] = 5.6

- b) A solution of 0.11 mole/l of bicarbonate (HCO₃⁻) and 0.1 mole/l of hydrochloric acid (HCl). (5 pts)

H ₂ CO ₃	↔	H ⁺	+	HCO ₃ ⁻
0		0.1		0.11
0.1		0		0.01
-x		x		x
0.1-x		x		x+0.01

$$\frac{[H^+][HCO_3^-]}{[H_2CO_3]} = K_a$$

$$\frac{x(x + 0.01)}{0.1 - x} = 4 \times 10^{-7}$$

Assume x is much smaller than 0.01, $\frac{0.01x}{0.1} = 4 \times 10^{-7}$
 $x = 4 \times 10^{-6}$

pH = -log[H⁺] = 5.4

- c) A solution of 0.1 mole/l of bicarbonate (HCO₃⁻), 0.1 mole/l of carbonic acid, and 0.3 mole/l of hydrochloric acid (HCl). (5 pts)

H_2CO_3	\longleftrightarrow	H^+	+	HCO_3^-
0.1		0.3		0.1
0.2		0.2		0
-x		x		x
0.2-x		x+0.2		x

Because carbonic acid is a weak acid, x must be much smaller than 0.2 mol/l, therefore we can say $[H^+] = 0.2$ mol/l. Or we can go through the calculation to prove it:

$$\frac{[H^+][HCO_3^-]}{[H_2CO_3]} = K_a$$

$$\frac{x(x + 0.2)}{0.2 - x} = 4 \times 10^{-7}$$

Assume x is much smaller than 0.2, $\frac{0.2x}{0.2} = 4 \times 10^{-7}$

$$x = 4 \times 10^{-7}$$

$$[H^+] = x + 0.2 \approx 0.2 \text{ mol/l}$$

$$pH = -\log[H^+] = 0.70$$

Formulas, facts, and constants you may find useful:

1. K_a of carbonic acid (H_2CO_3) = 4×10^{-7}
2. The expression for an acid equilibrium constant for a generic acid (HX) is $K_a = \frac{[H^+][X^-]}{[HX]}$