EAS 1600 - INTRODUCTION TO ENVIRONMENTAL SCIENCES

Fall Semester 2013

FINAL EXAM – December 9, 2013

- ❖ **Relevant formulas are included at the end of the exam.**
- ❖ **Place your name on each page.**
- ❖ **Answer all questions, and show all calculations and units where applicable.**
- ❖ **This is a closed-book exam; all are expected to comply with Georgia Tech Honor Code. Please also note that cell phone use or contact with any other person is not allowed.**

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

Print Name: _____

Signature: _____

Lab Section: _____

GT ID#_____

A

1. Multiple Choice. (4 pts each)

Choose the best answer to the following multiple choice questions

1. Approximately how many hours of sunlight will Norilsk, Russia (69° N) receive today?

    a. 6
    b. 10
    c. 0
    d. 8

2. What is the ratio of the noontime radiative flux that impacts St. Louis, MO (39° N) in summer (June 22) to that on an equinox?

    a. 0.6
    b. 1.2
    c. 2.1
    d. 0.5

3. The radiative flux emitted by the surface of the Mercury is 1452 W m^{-2}, what is the primary wavelength emitted by Mercury?
    a. 400 μm
    b. 2 μm
    c. 7.2 nm
    d. 7.2 μm

4. Approximately how many hours of sunlight will Bangkok, Thailand (14° N) receive on March 21?

    a. 14
    b. 10
    c. 12
    d. 18

5. At noon today what is the approximate incident angle (q) of the Sun in Canberra, Australia today (35° S)?

    a. 12 $^\circ$
    b. 35 $^\circ$
    c. 55 $^\circ$
    d. 59 $^\circ$

6. A star appears red, what is the best estimate of its temperature?
    a. 4100 K
    b. 4 K
    c. 14500 K
    d. 7200 K

7. You are flying on a plane at an altitude of 9000 m, what is the difference in pressure compared to sea level?
    a. 675 mb
    b. 32,500 Pa
    c. 0.675 atm
    d. 0.1 atm

8. Which of the following is NOT a Greenhouse Gas?
    a. Chlorofluorocarbons (CFCs)
    b. Carbon Dioxide (CO_2)
    c. Helium (He)
    d. Ozone (O_3)

9. Which of the following statements is NOT correct?
    a. Cloud drops will form on CCN when the relative humidity is <100%
    b. Cloud drops will form on CCN when the relative humidityis ≥100%
    c. Clouds will not form if the relative humidity is< 100%

10. As the temperature of a blackbody increases, the spectrum of radiation moves to _____.
    a. Lower frequency
    b. Longer wavelength
    c. Infrared direction
    d. Shorter wavelength

11. An air parcel contains 25 grams of water vapor. As the air parcel ascends the cloud forms. The formation of the cloud _____ the air by the transfer of _____ .
    a. heats, 62500 kJ
    b. heats, 62.5 kJ
    c. cools, 8300 J
    d. cools, 83 kJ

12. Where would you expect to find the least dense ocean waters?
    a. At the Equator
    b. The High Latitude North Atlantic Ocean
    c. The Mid-Latitude Atlantic Ocean
    d. Near the Pacific High

13. The direction of the gyre in the North Pacific is _____ and is driven by the circulation about the _____.

     a) clockwise; Bermuda High
     b) clockwise; Pacific High
     c) counterclockwise; Bermuda High
     d) counterclockwise; Icelandic Low

14. Which of these ocean currents is warm?
     a. California
     b. Gulfstream
     c. The current along the west coast of South America
     d. Labrador

15. Where would you expect to find the least amount of ocean nutrients near the ocean surface?
     a. High latitude ocean
     b. Equatorial ocean
     c. Near the west coast of South America
     d. Near river deltas

16. In the long-term carbon cycle what is the major source of carbon dioxide to the atmosphere?
     a. Respiration
     b. Fossil fuel combustion
     c. Rock weathering
     d. Volcanism

17. Which of the following is a metamorphic rock?
     a. Granite
     b. Limestone
     c. Basalt
     d. Marble

18. Which of the following in the ocean limits the productivity of ocean biota?
     a. Phosphate
     b. Bicarbonate
     c. Chloride
     d. Calcium

19. Which of the following minerals is likely to weather the fastest?
    a. Feldspars
    b. Calcite
    c. Quartz
    d. Olivine

20. Which of the nitrogen species below is the most oxidized?
    a. NH_3
    b. NO_3^-
    c. N_2O
    d. HNO_2

21. Which of the mountain ranges is volcanic?
    a. Himalayas
    b. Appalachians
    c. Andes

22. Which of the following is due to a convergent ocean-ocean plate boundary?
    a. Aleutian Islands
    b. Andes Mountains
    c. Mid-ocean ridge
    d. The Appalachians

23. Near which type of plate boundary do you expect to find shield volcanoes?
    a. Continent-Ocean Convergent
    b. Continent-Continent Convergent
    c. Ocean-Ocean Convergent
    d. Transform fault

24. Where do you expect to find the most saline ocean waters?
    a. The Mediterranean sea
    b. Tropical Atlantic
    c. Mid-Latitude North Atlantic
    d. Tropical Pacific

25. Where would you expect clear skies to dominate?
    a. 55 to 65° N
    b. 25 to 35° N
    c. 5° S to 5° N

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

a. If organic matter is buried without being oxidized, there is an increase of O_2 concentration in the atmosphere. _____

b. Shield volcanoes are more likely to erupt compared with stratovolcanoes. _____

c. Most of the bicarbonate in the ocean is formed from rock weathering. _____

d. Milankovitch Cycles impact long term climate by affecting solar radiation received by the Earth._____

e. Sulfate aerosols emitted by volcanism can impact climate in long term._____

f. In the short term carbon cycle only photosynthesis, deforestation, and decay add carbon to the atmosphere. _____

g. The largest reservoir of carbon is oceanic bicarbonate ion. _____

h. The prevailing wind direction at McMurdo, Antarctica ($72\,°S$) is from the East._____

i. In the long term rock weathering leads to warming of the climate. _____

j. Mauna Loa, Hawaii is a stratovolcano. _____

k. Density increases with depth in a stably stratified ocean. _____

l. H_2O is the greenhouse gas that traps the most outgoing radiation._____

m. Basalt is an igneous rock associated with ocean floor. _____

n. As the temperature of the Earth's surface increases, the rock weathering rate increases._____

o. As the Earth's tilt decreases, the polar regions are impacted by a larger solar flux during summer._____

27. Consider a balloon that floats at an altitude of 11 km and the surrounding temperature is 200 K. If the balloon has a volume of 4 m^3, what is its mass? (10 pts)

28. What would the effective temperature of the Earth be if its albedo were to increase to 0.8 and the Sun-Earth distance were to decrease by a factor of 2? (10 pts)

29. A very thin, square flat plate has sides of length 6 m and orbits the Sun at the same distance as Earth. If the plate's albedo is 0.3 and it is oriented such that the angle between the solar radiation and the plate surface is 25°. How much energy is absorbed the plate in one hour? How much energy is emitted in one hour? (20 pts)

30. Draw a systems diagram that includes: atmospheric oxygen, forest fires, and the carbon stored in soils. Indicate all feedbacks and loops. (5 pts)

31. Draw a diagram(s) of a <u>high pressure</u> system in the <u>Southern Hemisphere</u>. Be sure to show the horizontal (wind directions) and vertical motion. Label the compass directions on your diagram (i.e. North, etc). Indicate what type of weather is associated with this system and explain why. . (10 pts)

32. What is the mass of the Earth's atmosphere if the radius of the Earth is 6400 km? (10 pts)

Diagram of Short Term Carbon Cycle
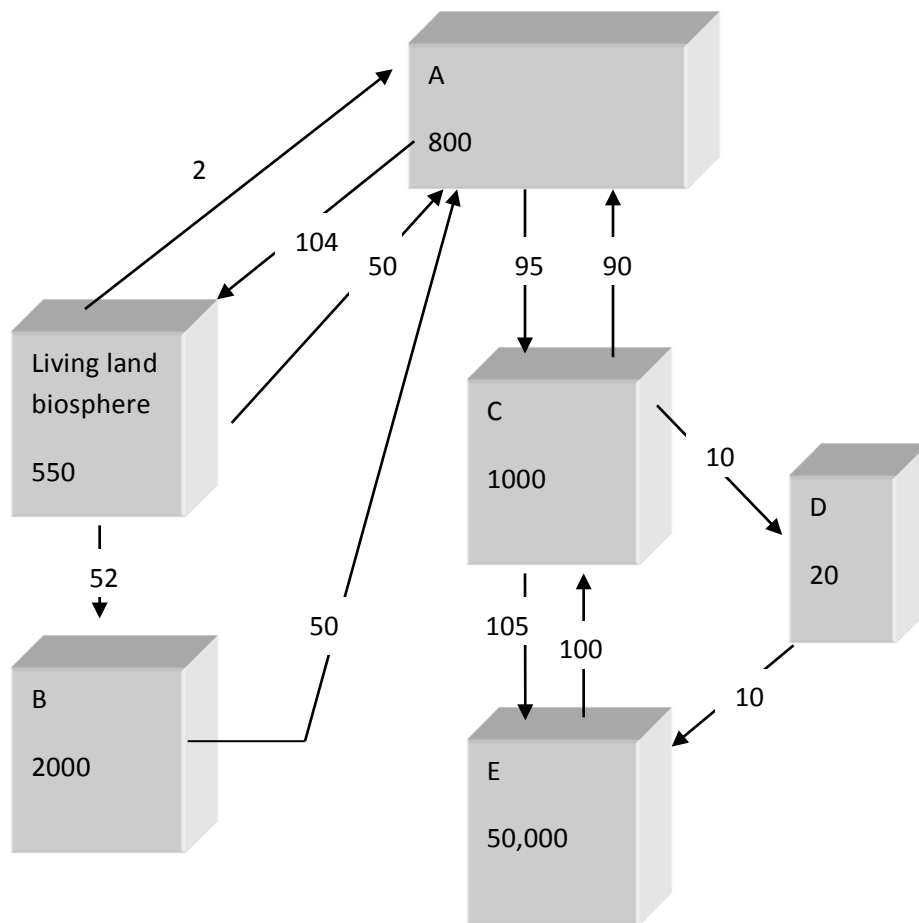
33. Answer the following questions according to the carbon cycle diagram above. Remember that the numbers in the boxes correspond to amounts in Gtons of carbon and the arrows are fluxes in units of Gtons/year. (15 pts)

a) Provide names for the carbon reservoirs labeled A, B, C, D, and E. (5 pts)

b) What are the residence times of carbon in reservoirs C and E, respectively? (2 pts)

c) Among all the reservoirs in the diagram, list all the reservoirs that should be increasing with time. (2 pts)

d) Identify the processes represented by the fluxes in and out of the reservoir labeled A. (6 pts)

34. A solution initially contains formic acid (HCOOH) and formate (HCOO⁻) each at a concentration of 0.02 mol/l.

a. What is the pH of the solution? (10 pts)

b. If 0.08 mol/l of HCl were added to the solution in part (a) what would be the pH? (10 pts)

c. If 0.008 mol/l of HCl were added to the solution in part (a) what would be the pH? (10 pts)

Equations

1. The latitude of a point is earth is defined as the angle defined by that point, the center of the Earth, and the Equator. For Example, Atlanta is at 34° N, The Equator is 0°, and the South Pole is 90° S.

2. $Pop(t) = Pop(t_o)e^{rt}$

population at time t related to original population at t_o and the growth rate constant - r

3. speed of light $= c = \lambda \upsilon = 3 \times 10^8$ m/s

where λ = wavelength and υ = frequency

4. energy of a photon $= E = h\upsilon = hc/\lambda$

where h = Planck's constant $= 6.63 \times 10^{-34}$ Js

5. $S(r)$ = radiant flux at a distance r from a point source $= S(r_o) [r_o/r]^2$

6. Surface area of a sphere with radius r; $A = 4\pi r^2$

7. λ_{max} = the wavelength (in μm) at which a blackbody at temperature T (in K) has its maximum radiant flux

$$= \frac{2898\,\mu mK}{T}$$

8. S = radiant flux leaving the surface of a blackbody at temperature T (in K)

$$= \sigma T^4$$

where σ = Stefan-Boltzman constant $= 5.67 \times 10^{-8}$ W/(m^2 K^4)

9. T_{eff} = planet's effective temperature $= [(S^*/4)(1/\sigma)(1 - albedo)]^{1/4}$

where (S^*) is the radiant flux impinging on the planet from its "sun"

for the Earth/Sun system S=1370 W/m^2

10. $S=S^o cos(q)$ where q is the angle of incidence of a radiation striking a surface. S^o is the flux of the radiation above the surface. S is the flux on the surface.

11. Pressure units 1 atm $= 1013$ mb $= 10^5$ Pa, 1 Pa $= 1$ kg m^{-1} s^{-2}

12. Ideal Gas Law $P = \rho R_m T$

where R_m is the gas constant for air $= 287$ J K^{-1} kg^{-1}

ρ is the gas density, for example the gas density at sea level is $\sim$1.2 kg m^{-3}

13. $P=P_0 exp(-z/H)$ is the barometric pressure law, where H=8 km.

14. 1.0 ft $= 0.3048$ meters

15. d=vt (d-distance, v-velocity, t-time)

16. for water the heat of condensation/evaporation $= 2500$ J/g, heat of melting/freezing $= 333$ J/g

17. $D=0.4A\rho_{air}v^2$ (D- drag force, A-cross sectional area, v-velocity, ρ_{air} – density of air)

16. For formic acid (HCOOH), $K_a = 1.8 \times 10^{-5}$

17. 1 ft $= .305$ m