

**EAS 1600 - INTRODUCTION TO ENVIRONMENTAL SCIENCES**

**Fall, 2014**

**Exam 2 – 10/6/14**

- < **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 – 10) by circling the appropriate answer.**

1. As an air parcel descends in the atmosphere it \_\_\_\_\_ and \_\_\_\_\_. (5 points)

- a) compresses, cools
- b) expands, cools
- c) expands, warms
- d) compresses, warms**

2. The atmospheric pressure at 5 km altitude is approximately \_\_\_\_\_. (5 points)

- a)  $2.3 \times 10^4$  Pa
- b) 150 mb
- c) 2.3 kPa
- d) 0.5 atm**

3. Which of the following cities do you expect is least likely to be hit by a hurricane? (5 points)

- a) Tokyo, Japan
- b) Cape Hatteras, NC
- c) New Orleans, LA
- d) San Francisco, CA**

4. What is the difference in air pressure between the top of Stone Mountain which is at an elevation of 1700 ft. and Decatur, GA which is at an elevation of 1000 ft.? (5 points)

- a) 0.94 atm
- b) 0.023 atm**
- c) 0.084 atm
- d) 15 Pa

5. A cylinder of compressed air has a pressure of 160 atm and a temperature close to room temperature. What is the density of the air? (5 points)

- a)  $1.2 \text{ kg m}^{-3}$
- b)  $190 \text{ g m}^{-3}$
- c)  $2.0 \text{ kg m}^{-3}$
- d)  $0.2 \text{ g cm}^{-3}$**

6. Which of the following describe subtropical high pressure area? Mark all that apply.  
(5 points)

- a) Rainy climate
- b) Dry climate**
- c) Rising air
- d) Sinking air**

7. Which of the following is a key property of a greenhouse gas in the Earth system?  
(5 points)

- a) absorbs ultraviolet radiation
- b) is less dense than air
- c) contains a carbon atom
- d) absorbs infrared radiation**

8. What is the pressure at 41 m below the surface of the ocean?  
(5 points)

- a) 5000 mb**
- b)  $5 \times 10^9$  Pa
- c) 128 atm
- d)  $1.1 \times 10^5$  Pa

9. What is the mass of the Earth's atmosphere assuming that the radius is  $10^4$  km?  
(5 points)

- a) 4000 tons
- b)  $1.3 \times 10^{13}$  kg
- c)  $1.3 \times 10^{19}$  kg**
- d)  $5 \times 10^{18}$  kg

10. The prevailing wind direction near Sydney, Australia ( $33^\circ$  S) is \_\_\_\_\_ and near Malaysia ( $2^\circ$  N) is \_\_\_\_\_.  
(5 points)

- a) East, East
- b) North, South
- c) West, East**
- d) East, West

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

- a. Low pressure systems are associated with precipitation. \_\_\_\_T\_\_\_\_
- b. As the temperature of the atmosphere increases the atmospheric pressure increases. \_\_\_\_F\_\_\_\_
- c. Hot air is more dense than cold air at the same pressure. \_\_\_\_F\_\_\_\_
- d. In general, high levels of precipitation are found at the latitude of 30° S. \_\_\_\_F\_\_\_\_
- e. The Bermuda High brings warm, humid air to the East Coast. \_\_\_\_T\_\_\_\_
- f. The ocean near the coast of Alaska is dominated by a persistent low pressure system. \_\_\_\_T\_\_\_\_
- g. Greenhouse gases efficiently absorb visible radiation. \_\_\_\_F\_\_\_\_

12. Assuming that Atlanta is about 355 m above sea level. Estimate the density of the air in this room.

(6 pts)

The pressure in Atlanta:

$$p = p^0 \exp\left(-\frac{z}{H}\right) = 1.013 \times 10^5 \text{ Pa} \times \exp(-355 \text{ m} / 8 \text{ km}) = 9.69 \times 10^4 \text{ Pa}$$

In addition, the room temperature is about 20 °C.

$$\rho = \frac{P}{TR_d} = \frac{96900}{(20 + 273) \times 287} \text{ kg/m}^3 = 1.15 \text{ kg/m}^3$$

13. A planet has an effective temperature of 380 K, an albedo of 0, and has an atmosphere composed of greenhouse gases that don't absorb any solar radiation (i.e. incoming radiation) but absorb all of the radiation emitted by the planet. Estimate the surface temperature of the planet. A diagram of the radiation balance is probably useful.

(10 pts)

Consider energy balance for the atmosphere,

$$\sigma T_{surf}^4 = 2\sigma T_{atm}^4, \text{ and } T_{atm} = T_{eff}$$

$$\text{So } T_{surf} = 2^{1/4} T_{eff} = 451.9 \text{ K}$$

14. A balloon floats at an altitude of 7.4 km and has a volume of  $10 \text{ m}^3$ . Assuming an air temperature of 255 K what is the buoyant force on the balloon? What is the maximum mass of the balloon?

(10 pts)

Use barometric law to solve pressure at 7.4 km.

$$p = p^0 \exp\left(-\frac{z}{H}\right) = 1.013 \times 10^5 \text{ Pa} \times \exp(-7.4 \text{ km}/8 \text{ km}) = 4.02 \times 10^4 \text{ Pa}$$

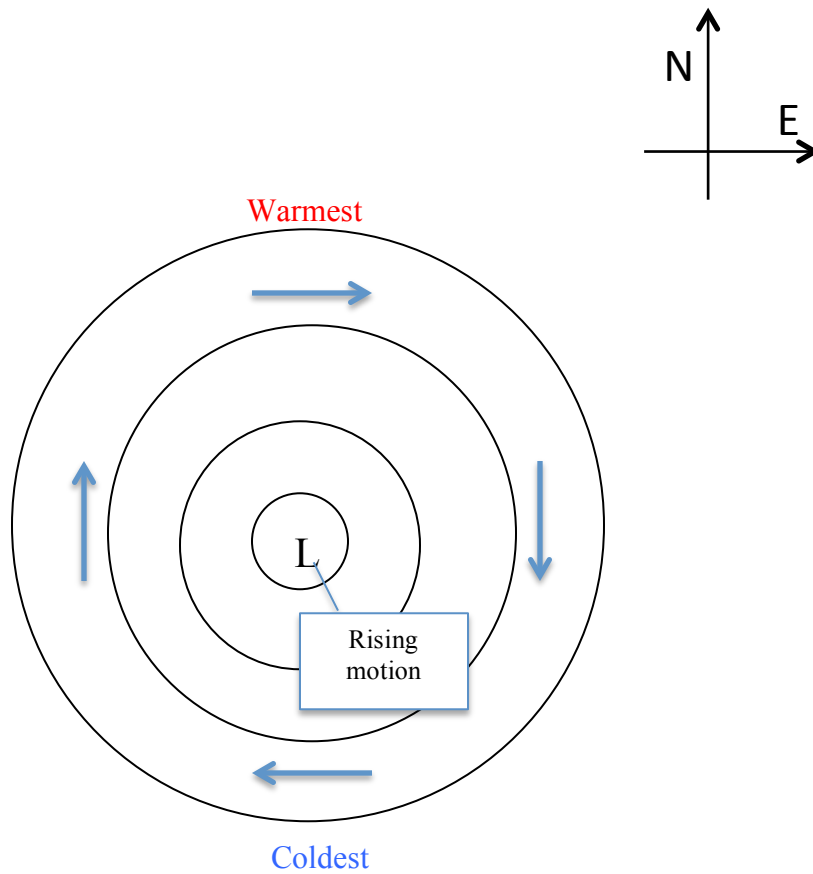
The density of the outside air and also of the air inside the balloon is

$$\rho = \frac{P}{TR_d} = \frac{4.02 \times 10^4}{255 \times 287} \text{ kg/m}^3 = 0.55 \text{ kg/m}^3$$

$$\text{Buoyant force} = \text{max Weight} = \rho V g = 0.55 \times 10 \times 9.8 \text{ N} = 53.9 \text{ N}$$

$$\text{Max mass} = \rho V = 5.5 \text{ kg}$$

15. Draw a diagram of a low pressure system in the southern hemisphere. Indicate the horizontal flow pattern about the system with arrows showing the wind directions. Also indicate the vertical motion of air associated with the system. Label on the diagram where you expect to find the warmest and the coldest air. Be sure and pay attention to the compass directions indicated below.
- (10 pts)



**Formulas, facts, and constants you may find useful:**

1. The latitude of a point on 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. Surface area of a sphere with radius  $r$ ;  $A = 4\pi r^2$ ,

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

4. Ideal Gas Law  $P = \rho R_d T$

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

$\rho$  is the gas density.

For example the density of air is  $1.2 \text{ kg m}^{-3}$  at 1 atm. and 20 C.

5.  $P = P^0 \exp(-z/H)$  is the barometric pressure law, where  $H=8 \text{ km}$  and  $z$  is altitude

6.  $1.0 \text{ ft} = 0.3048 \text{ meters}$

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

8.  $g = 9.8 \text{ m s}^{-2}$

9. Volume of a sphere =  $4/3\pi r^3$

10. Density of liquid water =  $1 \text{ g cm}^{-3}$