Name: ______________________ **Laboratory Section:** ______________________

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LAB EXERCISE 12 Atmospheric Humidity

Lab Exercise and Activities

SECTION 1

Relative Humidity

1. The table on the right hand side of Figure 12.1 lists maximum specific humidity values for various temperatures. You can also use the table to find dew-point temperatures, if you know how many grams of water vapor per kilogram of air are present. Use the table to answer the following questions:

   a) What is the maximum specific humidity of a parcel of air at 0°C ? ___*3.8 g*___

   b) What is the maximum specific humidity of a parcel of air at 25°C? ___*20.0 g*___

   c) What is the dew-point temperature for a parcel of air with 3.8 g/kg? ___*0*___ °C

   d) What is the dew-point temperature for a parcel of air with 10.6 g/kg? ___*15*___ °C

2. The maximum specific humidity of air at −30°C is ___*0.3 g/kg*___ and the maximum specific humidity of air at −10°C is ___*1.8 g*___, therefore, the difference in maximum specific humidity between −30°C and −10°C is ___*1.5*___ g/kg. The maximum specific humidity of air at + 30°C is ___*27.1 g*___ and the maximum specific humidity of air at + 10°C is ___*7.6 g*___, therefore, the difference in maximum specific humidity between + 30°C and + 10°C is ___*19.5*___ g/kg.

3. You have an air mass at 10°C that contains 1.8 grams of water vapor per kilogram of air (g/kg) (*content*). Air at 10°C has a maximum specific humidity of ___*7.6 g/kg*___ grams (*capacity*). Using the equation given at the beginning of Section 1, what is the present relative humidity of this air mass?___*24*___%. Show your work:

   1.8/7.6 = 0.236
   0.236 rounds to 0.24, which equals 24%

4. What is the approximate dew-point temperature of the air mass in Question 3, ___*−10*___ °C? (What is the temperature for which 1.8 g/kg is the maximum capacity?) In other words, this air mass must cool down from its present temperature by ___*20*___ C° to achieve saturated conditions at the dew-point temperature. [Hint: The present temperature must cool down to the dew-point temperature for its water content to equal the air's water vapor capacity.]

5. Using the same air mass from Question 3, assume that it warms to 25°C on a hot afternoon and maintains the same vapor pressure content of 3.8 g/kg. What is the relative humidity of the air mass at this time? ___*19*___%. [Hint: Find the maximum specific humidity for air at 25°C.] Show your work:

   3.8/20.0 = 0.19 or 19%

6. Assuming that a different air mass has a relative humidity of 40% at a temperature of 25°C, what is the actual humidity content, expressed as g/kg? ___*5*___ g/kg. Thus, by knowing relative humidity and air temperature, relative humidity provides us with an indirect method of determining the actual water vapor content of the air.

7. Compare an air mass over the hot, arid Sahara with an average specific humidity of 12 g/kg, to an air mass in the moist midlatitudes with an average of 6 g/kg specific humidity.

   a) What is the relative humidity of a 40°C air mass with 12 g/kg specific humidity? ___*25%*___

   b) What is the relative humidity of a 10°C air mass with 6 g/kg specific humidity? ___*79%*___

8. Questions 8 through 11 show how relative humidity changes as cold, dry outside air is brought inside and warmed. Figure 12.1 shows that as air warms, the maximum specific humidity increases. Therefore, if the air warms but the amount of water vapor stays the same, its relative humidity decreases. Because of this, many people who live in climates with cold winters use humidifiers in their homes to make the air more comfortable.

   a) After looking at Figure 12.1, given outside conditions of 0°C and a specific humidity of 1.8 g/kg, what is the relative humidity of the atmosphere?

   47%

   b) What is the maximum specific humidity of air at 21°C? ___*15 g/kg*___

   c) What would the relative humidity of that air be if you brought it inside your house and warmed the air to 21°C?

   12%

9. Building engineers recommend that for optimal comfort, inside air should be 21°C, with 50% relative humidity.

   a) What is the specific humidity of air at 21°C with 50% relative humidity?

   7.5 g/kg

   b) How many grams of water vapor per kilogram of air would you need to add to bring the humidity up to 50% at 21°C, if the air initially had 1.8 g/kg of water vapor?

   5.7 g/kg

10. In Question 9, you found how many grams of water vapor you would need to add to 1 kg of air at 23°C to bring it up to 50% relative humidity. Now find out how much water vapor you would need to add to make your whole house comfortable. The average American house contains 544 m^3 of air, and at 21°C, 1 m^3 of air has a mass of 1.2 kg.

   a) What is the total mass of air inside the average house at 21°C?

   652.8 kg

   b) If the air inside your house is 23°C with 1.8 g of water vapor per kilogram of air, how many grams of water would you need to add to humidify all the air in your house to 50% relative humidity? [Hint: multiply the answer to Question 9b, how many grams per kilogram you'd have to add, by the answer to Question 10a, how many kilograms of air are in the average house]

   3721 g

c) There are 1000 g of water in 1 L. Given this, how many liters of water would you need to add?

3.7 liters

11. The EPA recommends ventilating your house so that 1/3 of the air in your house is exchanged every hour, or about 8 complete air changes per day. How many liters per day would you need to add to the air each day, if the air is changed 8 times?

29.6 liters per day

12. Questions 12 through 14 show how the relative humidity of warm, moist outside air changes when it is brought inside and cooled. People who live in hot, humid climates have to dehumidify their air to feel comfortable. As air cools, its relative humidity increases, making it feel muggy.

a) What would the specific humidity of the atmosphere be if it was 32°C with 90% relative humidity?

27.9 g

b) What is the dew point temperature for that air? *30–31°C*

13. If you brought air at 32°C with 90% relative humidity into your house and cooled it down to 21°C, how many grams of water would condense per kilogram of air? [Hint: you found the maximum specific humidity of air at 21°C in Question 8b, and you found the specific humidity of air at 32°C at 90% relative humidity in Question 12a]

27.9 − 7.5 = 20.4 g/kg

14. What is the total amount of water vapor that would condense from the air if the outside air were initially 32°C, with 90% relative humidity, and it were cooled down to 21°C and dehumidified down to 50% relative humidity, and you replaced all the air in your house? [Hint: use the value for the total mass of air in your house you found in Question 10a.]

13,317 g

SECTION 2

Measuring Relative Humidity

1. When using a sling psychrometer, what happens to the two thermometers as the psychrometer is spun? How do these changes make it possible to measure relative humidity? Explain.

The dry bulb measures the ambient air temperature. The water evaporating off the wick extracts heat energy in the form of latent heat of evaporation so that the wet-bulb temperature is depressed in an amount dependent on the air's ability to absorb water vapor—its relative humidity condition.

2. Using the psychrometric charts in Tables 12.1 and 12.2, determine the relationships asked for in **Table 12.3**. The first line is completed for you.

TABLE 12.3 Psychrometric relationships

(T) Dry-Bulb Temperature (°C)	(T_w) Wet-Bulb Temperature (°C)	($T - T_w$) Wet-Bulb Depression (C°)	(RH) Relative Humidity (%)	(T_{dp}) Dew-Point Temperature (°C)
–10°	–12°	[2°]	39%	–21°
5°	1°	***4°***	***45%***	***–6°***
5°	3.5°	***1.5°***	***78%***	***2°***
12.5°	8.5°	***4°***	***58%***	***4°***
25°	22°	***3°***	***77%***	***21°***
7.5°	***4.5°***	3.0°	***62%***	***1°***
17.5°	***16°***	***1.5°***	86%	***–15°***
25°	10°	***15°***	***7%***	***–14°***
50°	30°	***20°***	***23%***	23°
37.5°	33°	***4.5°***	***73%***	32°

SECTION 3

Measuring Relative Humidity and Temperature

Answers to questions 1–5 will vary with site.

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