

Laboratory Exercise #7 - Introduction to Atmospheric Science: The Seasons

Section A - Introduction:

This lab consists of both computer-based and noncomputer-based questions dealing with atmospheric science. Noncomputer-based questions reinforce your general knowledge and computer-based questions ask you to analyze data from the Underground Weather website (<http://www.wunderground.com/US/TX/Laredo.html>).

Section B – An Overview of the Seasons:

The seasons are caused by changes in solar radiation that occur throughout the year. Figure 1 illustrates the path of the earth around the sun during one year. Note that the axis of the earth is tilted at an angle of 23.5° . Because of this tilt the northern and southern hemispheres are inclined toward the sun for part of the year (summer) and away from the sun during winter. If the earth's axis were not tilted then the earth would not experience seasons because no hemisphere would ever be tilted toward or away from the sun.

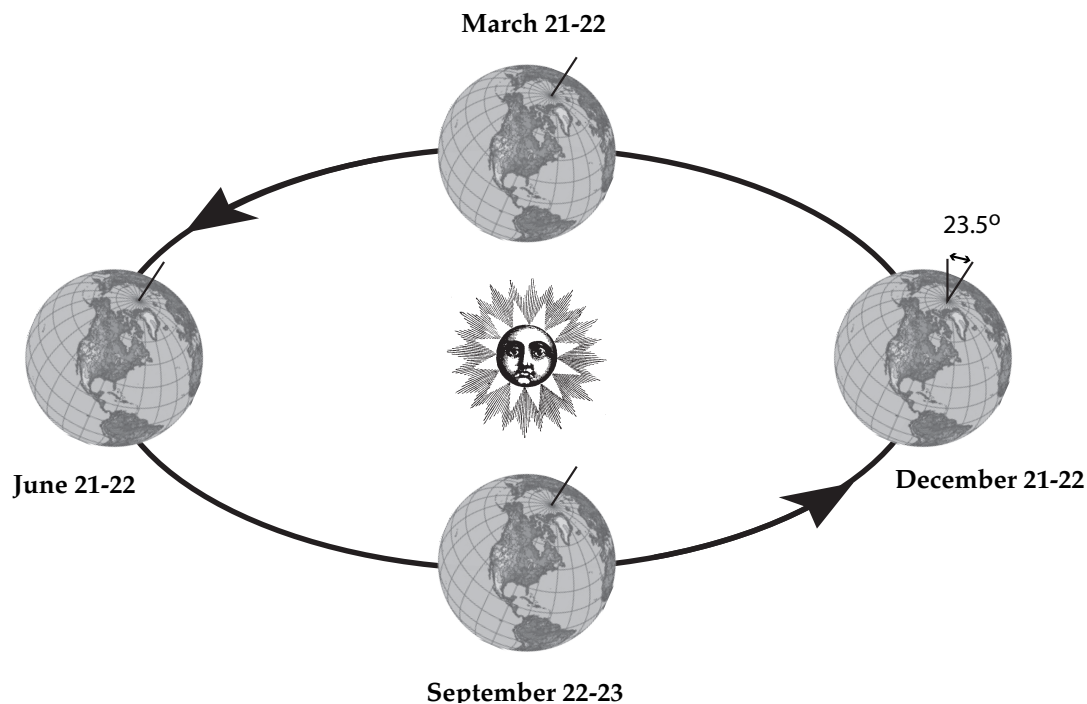


Figure 1. Diagram illustrating the earth's tilt with the earth at four positions in its orbit around the sun.

Additionally, the height of the sun above the horizon, called the solar angle, and length of day control the amount of solar radiation that the Earth's surface receives. During the summer the sun is higher above the horizon and the days are longer than in winter. Solar radiation is also influenced by latitude. In general, the solar angle is lower with increasing latitude (Figure 2). Note that the lower the solar angle is in an area the more area radiation is spread out and the lower the overall temperatures (Figure 3). These facts explain why summer is warmer than winter and also why the low latitudes are warmer than the higher latitudes.

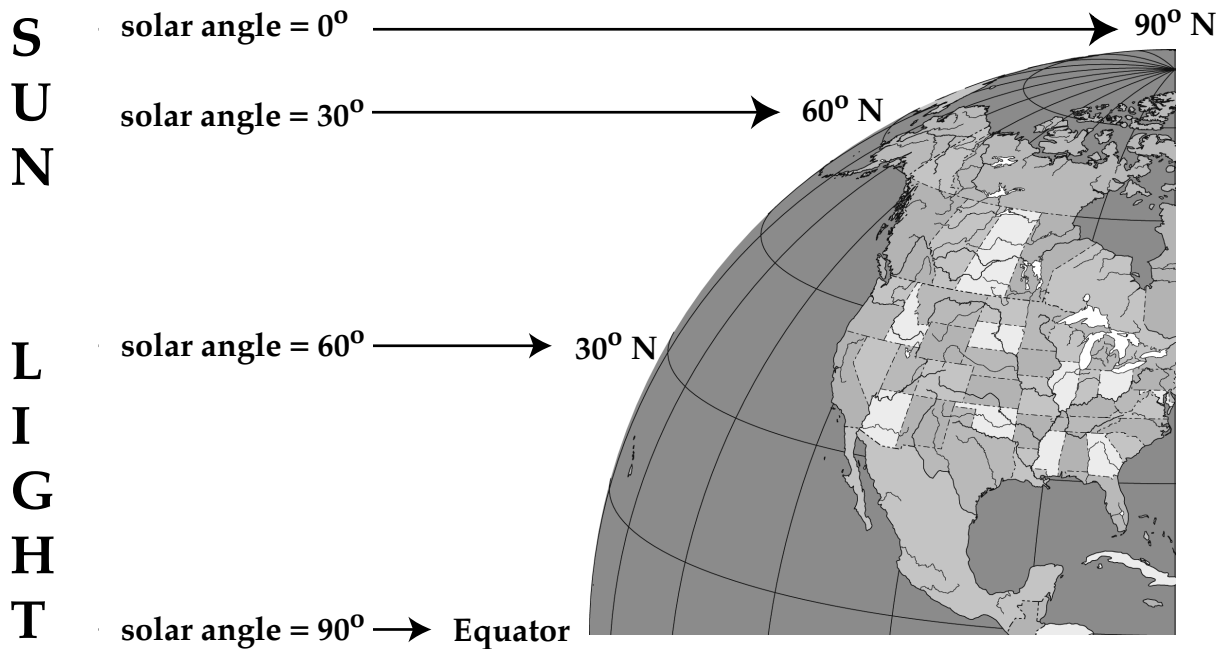


Figure 2. Solar angle at noon on the equinox.

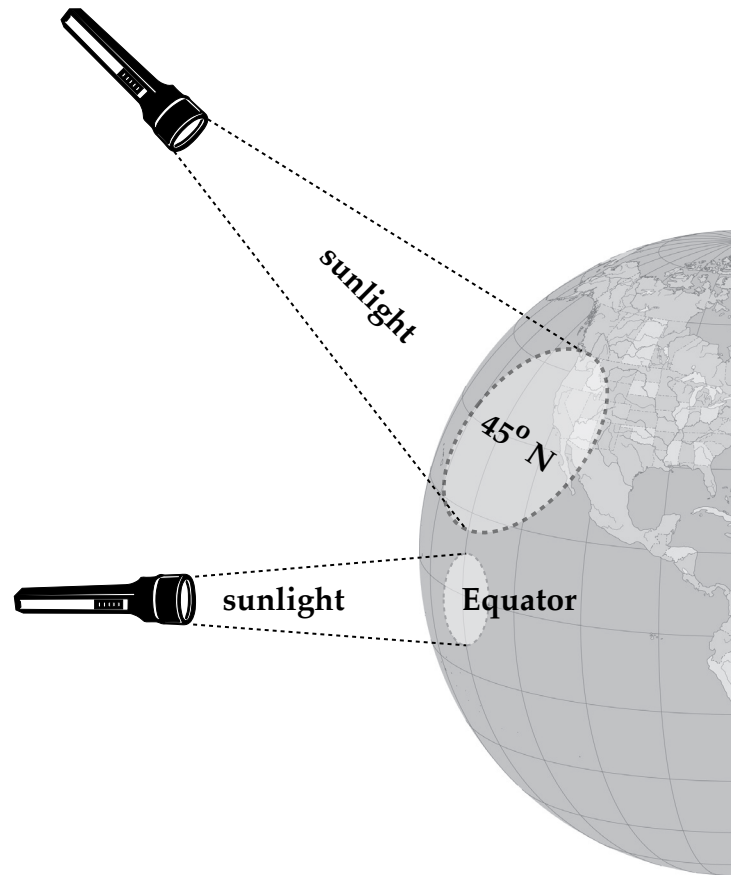


Figure 3. Diagram showing the relation between the solar angle and the area over which radiation is concentrated.

Questions:

1. Describe the tilt of the earth's axis. Does it change its orientation during the course of a year? Explain in detail! (Look at Figure 1).

2. Complete the table below by indicating the dates of the beginning of the seasons based on an examination of Figure 1.

	Winter	Spring	Summer	Fall
Northern Hemisphere				
Southern Hemisphere				

3. In the northern hemisphere, during the equinox, the sun is directly overhead at the equator. Determine the height of the sun above the horizon at noon at the following latitudes (Fig. 2).

Equator _____

60° N _____

30° N _____

90° N _____

4. In general, when is the sun highest above the horizon, during summer or winter? Explain!

Table 1 - Laredo, TX seasonal changes in daylight:

	Date and Length of Daylight
Longest Day – Summer Solstice	13.5 hrs
Shortest Day – Winter Solstice	10.5 hrs
Spring Equinox	12 hrs
Fall Equinox	12 hrs

5. During which season is the length of daylight the least? The greatest?
6. During the beginning of which 2 seasons is the length of daylight and night roughly the same?

Questions 7 to 11 focus on a database archive of weather data from Laredo, TX presented in the Underground Weather website (<http://www.wunderground.com/US/TX/Laredo.html>). From this database we developed Figure 4 that illustrates seasonal changes in extreme temperature in Laredo, TX.

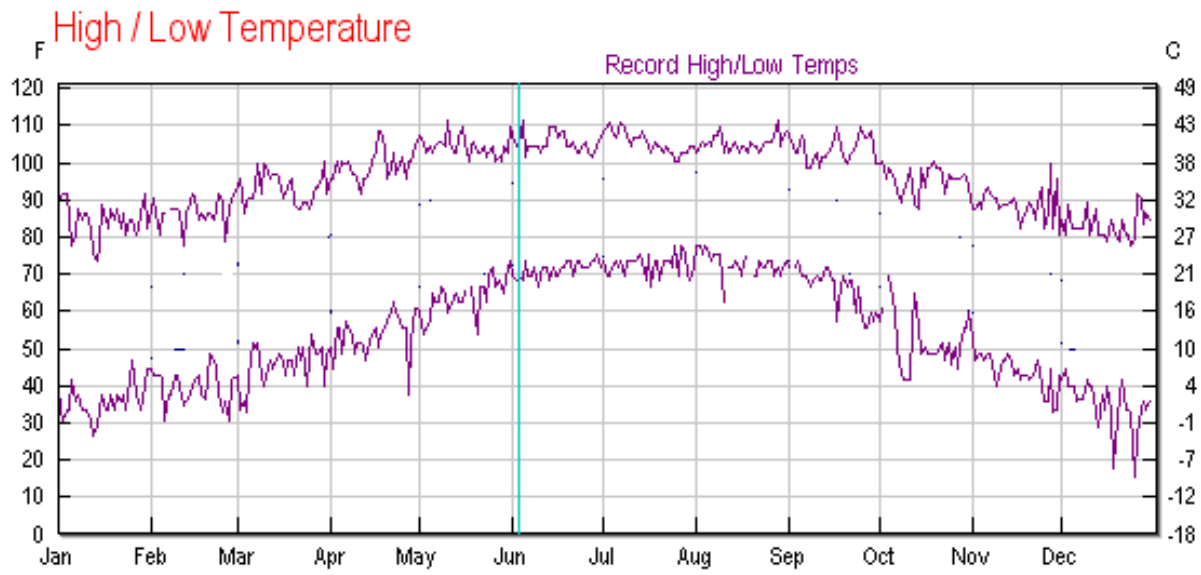


Figure 4. Daily record high and low temperatures for Laredo, TX. Chart obtained from the Underground Weather website (<http://www.wunderground.com/US/TX/Laredo.html>).

7. What is the record low temperature for the month of December.
8. What is the record low temperature for the month of April.
9. Explain how changes in the length of daylight and height of the sun above the horizon between summer and winter can explain the occurrence of extremely cold and hot temperatures in South Texas!
10. Plants rarely face freezing conditions in Laredo. List all the months in which temperatures have dropped to below 32 °F in Laredo, TX.

11. List all the months in which high temperatures does not reach 100 °F in Laredo, TX.

Section C – Seasonal Variations of Humidity:

Temperature is not the only weather attribute that changes with the seasons. Relative humidity, a measure of water vapor in the atmosphere, changes greatly not only with the seasons but within a 24 hour period. The mathematical expression for relative humidity is given as follows:

$$\text{RH \%} = 100\% [(\text{Water Vapor Content}) / (\text{Water Vapor Capacity})]$$

Where:

Water Vapor Content is the measured concentration of water vapor in the atmosphere measure in grams of H₂O vapor per kg of atmosphere

Water Vapor Capacity is the maximum concentration of water vapor that can be present in the atmosphere at a given temperature (also measured in grams of H₂O vapor per kg of atmosphere)

Another method for quantifying water vapor content in the atmosphere is the dew point temperature. The dew point temperature is defined as the temperature at which when air is cooled its relative humidity reaches 100%, which is the maximum RH % that can exist in the atmosphere. When the atmosphere reaches a RH % = 100% water vapor will condense from the atmosphere forming liquid (or solid) water depending upon temperature. Basically, the higher the dew point temperature the greater amount of water vapor that is present in the atmosphere.

Table 2. Relationship between temperature (F) and water vapor capacity (g / kg).

Temperature (°F)	Grams of water vapor per kg of air (g/kg)
-40	0.1
-22	0.3
-4	0.75
14	2
32	3.5
41	5
50	7
59	10
68	14
77	20
86	26.5
95	35
104	47

Questions:

12. Plot water vapor capacity data from Table 2 onto the graph (Figure 4).
13. As temperature increases water vapor capacity does the following? Examine Figure 5 and circle the correct answer.

Increases or Decreases

14. If water vapor content stays the same, describe the affect of decreasing temperature on relative humidity. Circle the correct answer.

Increases or Decreases

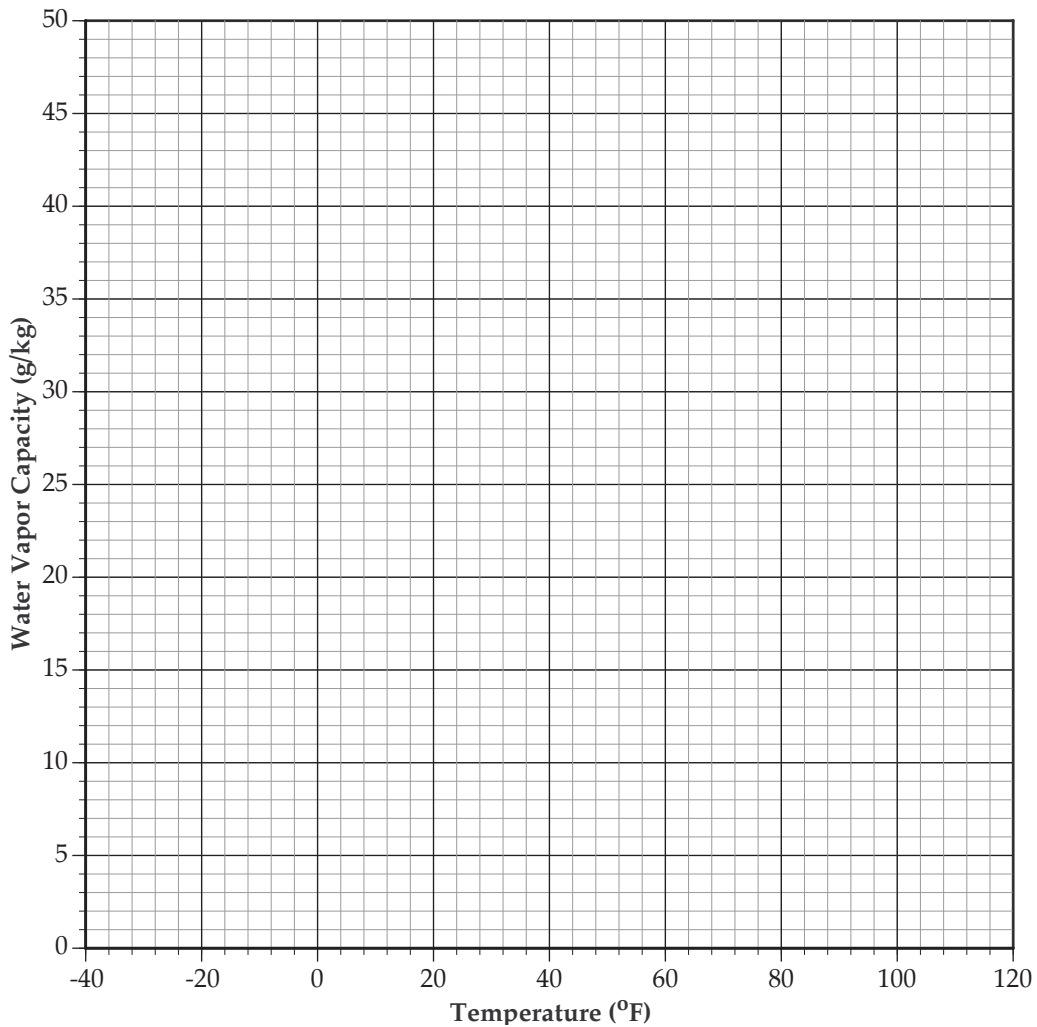


Figure 5. Graph showing relationship between temperature and water vapor capacity.

15. What is the maximum percentage for relative humidity in the earth's atmosphere?

16. What physically happens to water vapor when the relative humidity reaches its maximum value? Hint: it is the opposite of evaporation and no not necessarily precipitation.

17. Define dew point temperature.

Section D – Atmospheric Pressure

To understand the occurrence of storms, and for that matter fair, sunny weather, we need to learn about how air moves within the atmosphere. The movement of air is driven by differences in atmospheric pressure that occur within the atmosphere. Most people that have even casually glanced at a weather map from the television or internet notices the presence of areas of high pressure (**H**) and low pressure (**L**) depicted on weather maps.

Low Pressure – Has rising air and as the air rises it cools. As the air cools the humidity increases until it reaches 100%. When the humidity reaches 100%, water vapor condenses to form clouds and precipitation.

Or Low Pressure = Stormy Day

High Pressure – Has sinking air and as the air sinks it warms up. As the air warms up the humidity decreases, cloud formation is prevented and the weather is fair.

Or High Pressure = Sunny Day

Questions 18 to 32 focus on an archive of weather data from the Underground Weather website for Laredo, TX (<http://www.wunderground.com/US/TX/Laredo.html>). From this data we developed Figures 6 to 7.

For Questions 18 to 24 refer to Figure 6 on the next page.

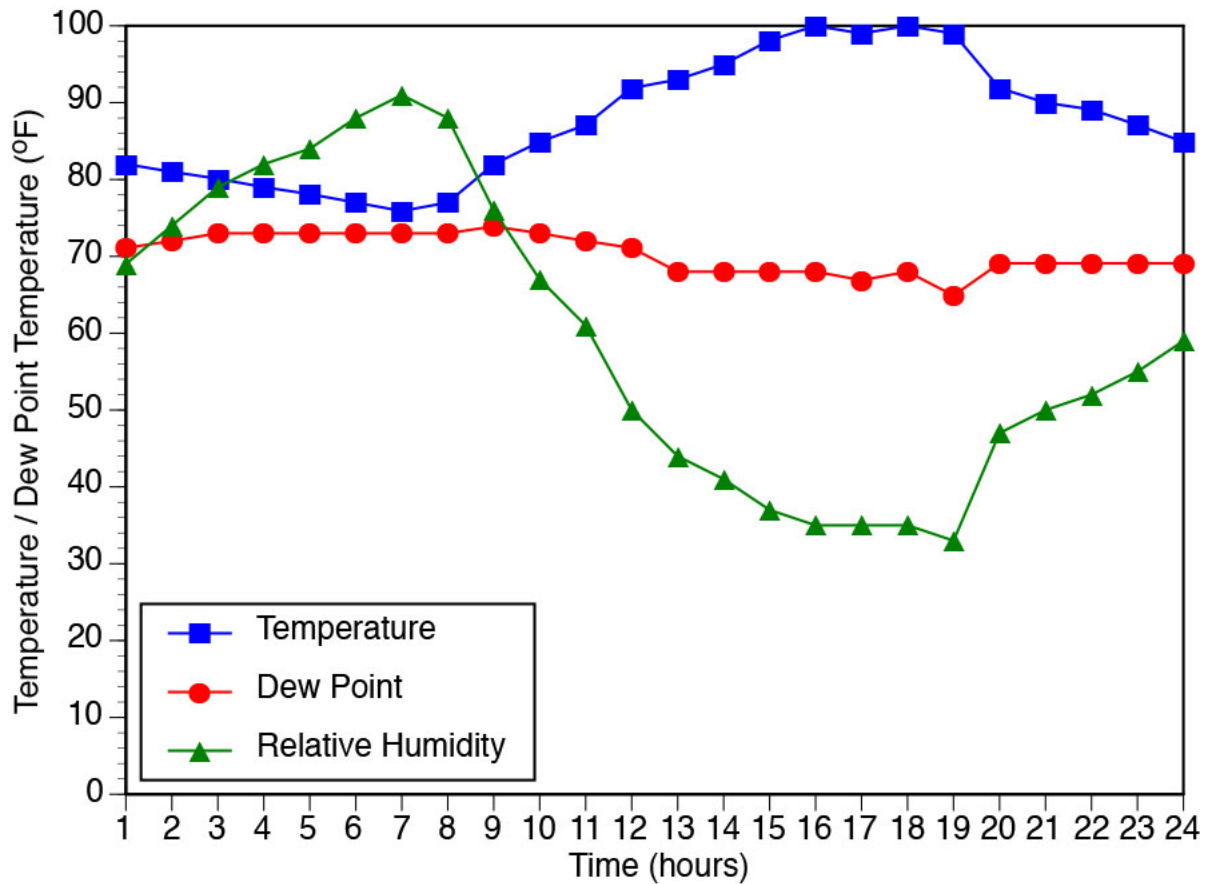


Figure 6 illustrates how air temperature (square), dew point temperature (circle), and humidity (triangle) varies on a typical sunny day (with no rain; 8/22/17) in Laredo, TX.

Questions:

18. At what time of day is the temperature the highest and lowest? List the temperature and the times when these temperature events occurred.

19. At what time of day is the humidity the highest and lowest? List the humidity and the times when these humidity events occurred.

20. Describe the relationship between temperature and humidity.

21. Does the temperature drop to the dew point temperature during this date. If so indicate the time at which this event occurs.

22. Is dew point relatively constant (within 6 °F) during this day or does it vary greatly. Explain in detail.

23. Comment in detail on whether the data in Figure 6 supports the statement: “ if dew point is constant then temperature will have an inverse relationship with humidity”.

24. The atmospheric pressure associated with 8/22/17 is what given the low relative humidities recorded on this date? Circle the correct answer.

High or Low

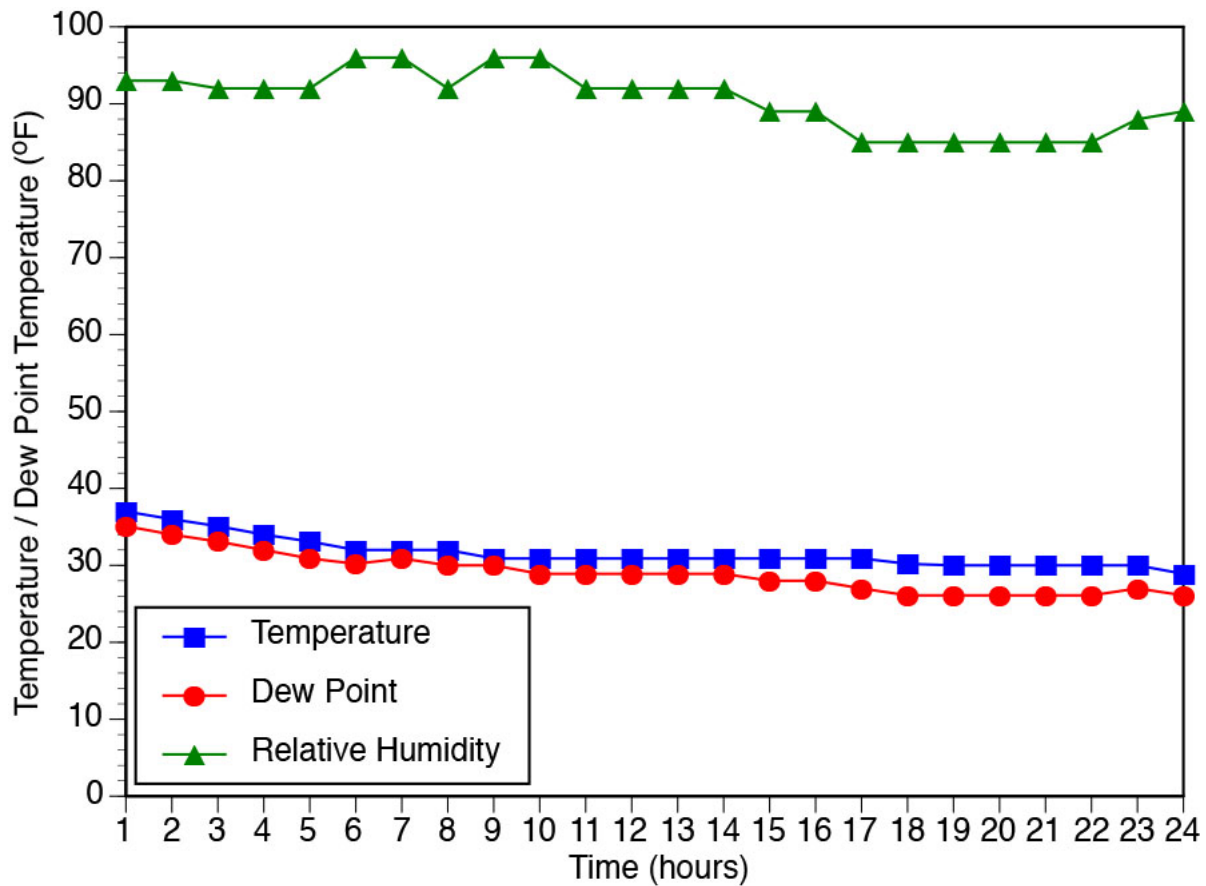


Figure 7 illustrates how air temperature (square), dew point temperature (circle), and humidity (triangle) varies on a day with winter precipitation (1/1/2018) in Laredo, TX.

For Questions 25 to 30 refer to Figure 7 and Table 3. Draw a horizontal line on Figure 7 at 32 °F.

25. At what time of day is the temperature lowest? List the temperature and the time when this event occurred.
26. Unlike high pressure days when the time of the lowest temperature is always at dawn. During low pressure days this is not always the case. Based on your answer to question 25 is the weather on 1/1/2018 consistent with high or low pressure. Explain in detail.

Examine Table 3 below and answer the following question 27 to 29.

Table 3 - Liquid equivalent precipitation on 1/1/2018 in Laredo Texas.

Hour	Precipitation (in)	Precipitation Type
1	0.01	
2	0	
3	0.01	
4	0.02	
5	0.01	
6	0.02	
7	0.02	
8 to 24	0	

27. On Table 3, during the hours in which precipitation occurred indicate if it was rain or snow. Note water freezes at 32 °F.

28. At what times of day is the humidity the lower (< 90%)? List the range of times when this occurred.

29. During the period with relatively low humidity is there any precipitation. Does this make sense. Explain!

30. The atmospheric pressure associated with 1/1/18 is? Circle the correct answer.

High or Low

Record the following information for next week's laboratory

Examine Figure 6 and at 16:00 hours on 8/22/17 determine the following:

Air Temperature _____ °F

Dew Point Temperature _____ °F

Sky Cover (Clear or Overcast) _____

Examine Figure 7 and at 7:00 hours on 1/1//18 determine the following:

Air Temperature _____ °F

Dew Point Temperature _____ °F

Weather _____

Sky Cover (Clear or Overcast) _____