Water Vapor Capacity of Air

We are interested in assessing the amount of water vapor in the air. In this exercise, you will be using Specific humidity, Relative humidity and Dew Point to show how much water vapor is in the air. The exercises will help you to understand the concept of water vapor content (how much water vapor the air is actually holding) in comparison to water vapor capacity (the maximum amount of water vapor that the air can hold). The water vapor capacity depends on the temperature of the air. Table 1 presents Specific Humidity values at different temperatures. This table can be used to read off two different values.

- If using the **air temperature**, then the specific humidity value will be the air's **capacity** (in grams of water in a kilogram of air).
- If using the **dew point temperature**, then the specific humidity value will be the air's **content** (in grams of water per kilogram of air)..

Table 1   Specific humidity of a kilogram of air (at average sea level pressure)

Temp. (°C)	Temp. (°F)	Grams of water vapor per kg of air (g/kg)
-40	-40	0.1
-35	-31	0.2
-30	-22	0.3
-25	-13	0.51
-20	-4	0.75
-10	14	1.8
0	32	3.8
5	41	5
10	50	7.8
15	59	10
20	68	15
25	77	20
30	86	27.7
35	95	35
40	104	49.8

1. Using Table 1, what is the water vapor **capacity** of a kilogram of air at each of the following air temperatures?

      35°C: _____ grams/kilogram
      77°F: _____grams/kilogram
      0°C: _____ grams/kilogram
    -35°C: _____ grams/kilogram

2. The relationship between temperature and saturation is not linear. To demonstrate this, we will raise the air temperature of a kilogram of air 10°C in both of the following cases. Note what happens when different temperatures are used.   Circle your answers.
    a. From 5°C to 15°C, the water vapor capacity (increases, decreases) by (5, 8) grams.
    b. From 25°C to 35°C, the water vapor capacity (increases, decreases) by (15, 20) grams.

3. Based on the last two questions, what can you say about the relationship between the water vapor capacity of air and the temperature of the air.

_____
_____

Relative Humidity

Relative humidity is a very common measurement that is used to describe how much water vapor is in the air. In general, it expresses how close the air is to reaching its water vapor capacity. Relative humidity is the ratio of the air's water vapor content (amount actually in the air) to its water vapor capacity at a given temperature, expressed as a percent.   The general formula is:

Relative Humidity (%) = (Water vapor content / Water vapor capacity) * 100%

4. Using Table 1, and the formula for relative humidity to determine the relative humidity for each of the following situations of identical temperature.

Air Temperature	Water Vapor Content	Water Vapor Capacity	Relative Humidity
15°C	2 g/kg	g/kg	%
15°C	5 g/kg	g/kg	%
15°C	7 g/kg	g/kg	%

5. From question 4, if the temperature of air remains constant, adding water vapor will (raise, lower) the relative humidity, while removing water vapor will (raise, lower) the relative humidity. Circle your answers.

6. Use Table 1 and the formula for relative humidity to determine the relative humidity for each of the following situations of identical water vapor content.

Air Temperature	Water Vapor Content	Water Vapor Capacity	Relative Humidity
25°C	5 g/kg	g/kg	%
15°C	5 g/kg	g/kg	%
5°C	5 g/kg	g/kg	%

7. From question 6, if the amount of water vapor in the air remains constant, cooling the air will (raise, lower) the relative humidity, while warming the air will (raise, lower) the relative humidity. Circle your answers.

8. In the winter, air is heated in homes. What effect does heating the air have on the relative humidity inside the home? What can be done to lessen this effect?
    _____
    _____

9. Explain why a cool basement is humid (damp) in the summer.
    _____
    _____

10. Write a brief statement describing each of the two ways that the relative humidity of air can be changed.

    1) _____
    2) _____

One of the misconceptions concerning relative humidity is that it alone gives an accurate indication of the amount of water vapor in the air. For example, on a winter day if you hear on the radio that the relative humidity is 90%, can you conclude that the air contains more moisture than on a summer day which records a 40% relative humidity? Completing question 11 will help you to find the answer.

11. Use Table 1 to determine the water vapor content for each of the following situations. As you do the calculations, keep in mind the definition of relative humidity.

Summer	Winter
Air temperature = 77°F	Air temperature = 41°F
Capacity = g/kg	Capacity = g/kg
Relative humidity = 40%	Relative humidity = 90%
Content = g/kg	Content = g/kg

12. Explain why relative humidity does not give an accurate indication of the amount of water vapor in the air.

_____
_____

Dew Point Temperature

Air is saturated when it has reached its water vapor capacity and contains all the water vapor that it can hold at a particular temperature. In saturated air, the water vapor content equals its capacity. The temperature at which air is saturated is called the dew point temperature. Put another way, the dew point is the temperature at which the relative humidity of the air is 100%.

   Previously in question 6, you determined that a kilogram of air at 25°C, containing 5 grams of water vapor, had a relative humidity of 25% and was not saturated. However, when the temperature was lowered to 5°C, the air had a relative humidity of 100% and was saturated. Therefore, 5°C is the dew point temperature of the air in that example.

13. By referring to Table 1, what is the dew point temperature of a kilogram of air that contains 7.8 grams of water vapor?

        Dew point temperature = _____°C

14. What is the relative humidity and dew point temperature of a kilogram of 25°C air that contains 10 grams of water vapor?

        Relative humidity = _____ %

        Dew point temperature = _____°C