Part B – Adiabatic Processes

As you have seen in Part A, the key to causing water vapor to condense is to cool the air to its dew-point temperature. This is necessary before precipitation can occur. In nature, when air rises, it encounters less pressure, so it expands, and it cools. The reverse is also true. Air that descends encounters higher pressures, is compressed, and will warm. Temperature changes brought about solely by expansion or compression are called *adiabatic* temperature changes.

Air with a temperature above its dew point (unsaturated air) cools by expansion at a rate of **1 °C per 100 meters of changing altitude.** This is the **dry adiabatic lapse rate**. After the dew point temperature is reached, continued cooling cause condensation to occur. Latent heat that has been stored in the water vapor will be released. The heat being released by the condensing water slows down the rate of cooling of the air. Rising saturated air will continue to cool by expansion, but at a lesser rate of about **0.5 °C per 100 meters of changing altitude** – the **wet adiabatic lapse rate**. Descending air will always warm at the dry adiabatic lapse rate. This is because, as it warms, its water vapor capacity increases, and it is no longer saturated. (See Table 3 for demonstration of this effect.)

Figure 2 shows the movement of a parcel of air, starting at sea level with a temperature of 15ºC and a relative humidity of 50%. The air is forced to rise over a 5,000 meter mountain and descend to a plateau 2,000 meters above sea level on the opposite (leeward) side. Answer the questions on the following page. While doing so, think about the parallels between this problem and the orographic effect in western Oregon.

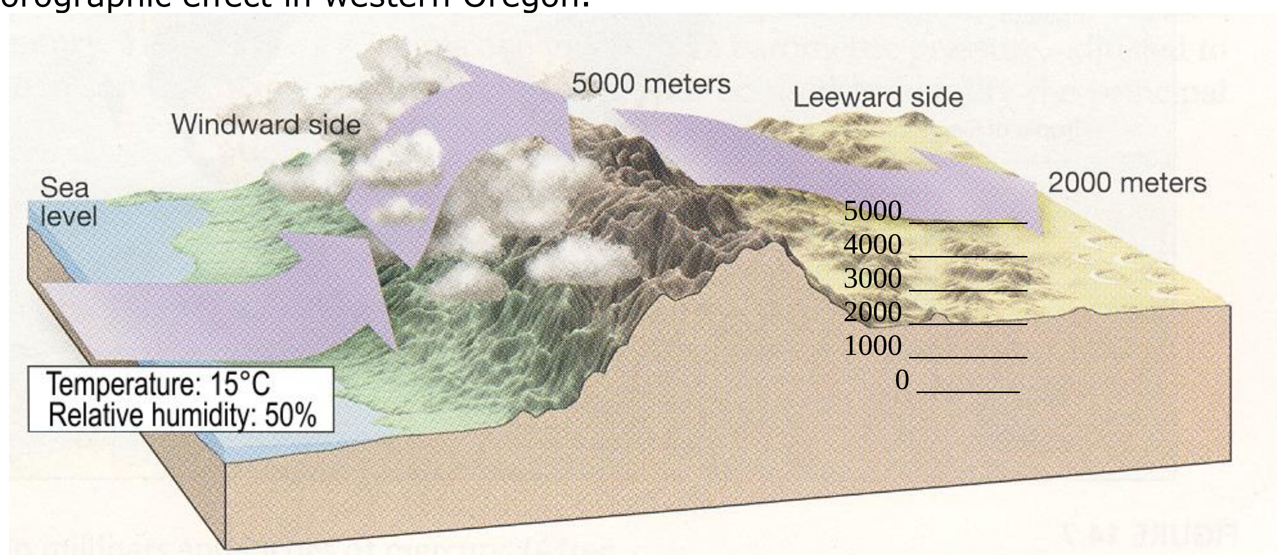

Figure 2: Adiabatic processes result in condensation associated with a mountain barrier.

We will take a parcel of air on a trip over the mountain. These questions must be done in order because the conditions from the previous question influence the answers for following questions. First, let us get our starting conditions from **Figure 2 on page 1.11 and Table 1 on page 1.3.** For **Bold this/that** questions you need to CIRCLE YOUR ANSWER.

Questions:

1. What are our **starting conditions** at sea level (0 elevation) on Figure 2?

Starting Temperature = ____________ ºC

Water Capacity at that temperature (Table 1 on 1.3) = ____________ g/kg

Relative Humidity at start point (Figure 2) = _____________%

That relative humidity then means actual content is = ____________ g/kg

Temp that actual content would saturate air (Table 1) =_________ ºC

(Note this last value is now our target for the following section)

2. The air at sea level is (**SATURATED** / **UNSATURATED**).
3. The air will initially (**WARM** / **COOL**) as it rises over the windward side of the mountain. It changes temperature at the (**WET** / **DRY**) adiabatic lapse rate, which is _______________ ºC per 100 meters.
4. The rising air will reach its dew point temperature (last line in question 1 above) at an elevation of _________________ meters and water vapor will begin to (**CONDENSE** / **EVAPORATE**).
5. From the altitude where condensation begins to occur, to the top of the mountain, the rising air will continue to expand and will (**WARM** / **COOL**) at the (**WET** / **DRY**) adiabatic lapse rate of _____________ ºC per 100 meters.
6. The temperature of the rising air at the summit of the mountain (elevation 5000 meters) will be _______________ ºC.
7. When the air begins to descend on the leeward side of the mountain, it will be compressed and its temperature will (**INCREASE** / **DECREASE**).
8. Assume that the relative humidity of the air is **below 100%** during its entire descent to the plateau. The air will be (**SATURATED** / **UNSATURATED**) and will warm at the (**WET** / **DRY**) adiabatic lapse rate of about _______________ ºC per 100 meters.
9. As the air descends and warms on the leeward side of the mountain, its relative humidity will (**INCREASE** / **DECREASE**)
10. The air's temperature when it reaches the plateau at 2,000 meters will be ______________ ºC.

ES106 LAB PART B

The water vapor capacity of air is directly related to, and limited by, its temperature. The table below presents the water vapor capacity of a kilogram of air at various temperatures. Use the table to answer the following questions.

Table 1: Water vapor capacity of a kilogram of air at average sea level pressure.

Temperature (ºF)	**Temperature (ºC)**	**Grams of water vapor per kg of air (g/kg)**
- 40	- 40	0.1
- 22	- 30	0.3
-4	- 20	0.75
14	- 10	2
32	0	3.5
41	5	5
50	10	7
59	15	10
68	20	14
77	25	20
86	30	26.5
95	35	35
104	40	47