Name: ______________________ Laboratory Section: ______________________

Date: ______________________ Score/Grade: ______________________

Video
Exercise 13
Pre-Lab Video
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LAB EXERCISE Stability and Adiabatic Processes

Lab Exercise and Activities

SECTION 1

Atmospheric Stability

1. Describe the general relationship between the ELR and atmospheric stability. For which ELR values will the atmosphere always be stable? Unstable?

On the graphs provided in **Figure 13.2**, *plot* the following data, using colored pencils to distinguish the different rates. Begin with a surface temperature of 25°C noted on all three graphs labeled a, b, and c. Please use these colors: ELR = green pencil; DAR = red pencil; MAR = blue pencil.

a) Plot an environmental lapse rate of 11 C° per 1000 m, DAR of 10 C° per 1000 m, MAR of 6 C° per 1000 m. This graph is completed for you.

b) Plot an environmental lapse rate of 4.5 C° per 1000 m, DAR of 10 C° per 1000 m, MAR of 6 C° per 1000 m.

c) Plot an environmental lapse rate of 8 C° per 1000 m, DAR of 10 C° per 1000 m, MAR of 6 C° per 1000 m.

2. Using Figure 13.1 and your graphs in Figure 13.2, note the relationship between the environmental lapse rates on each graph you made and the DAR and MAR. Determine which stability condition describes each of the three graphs you have completed. *Hint:* Compare each ELR plotted with the relations in Figure 13.2.

Stability graph (a)

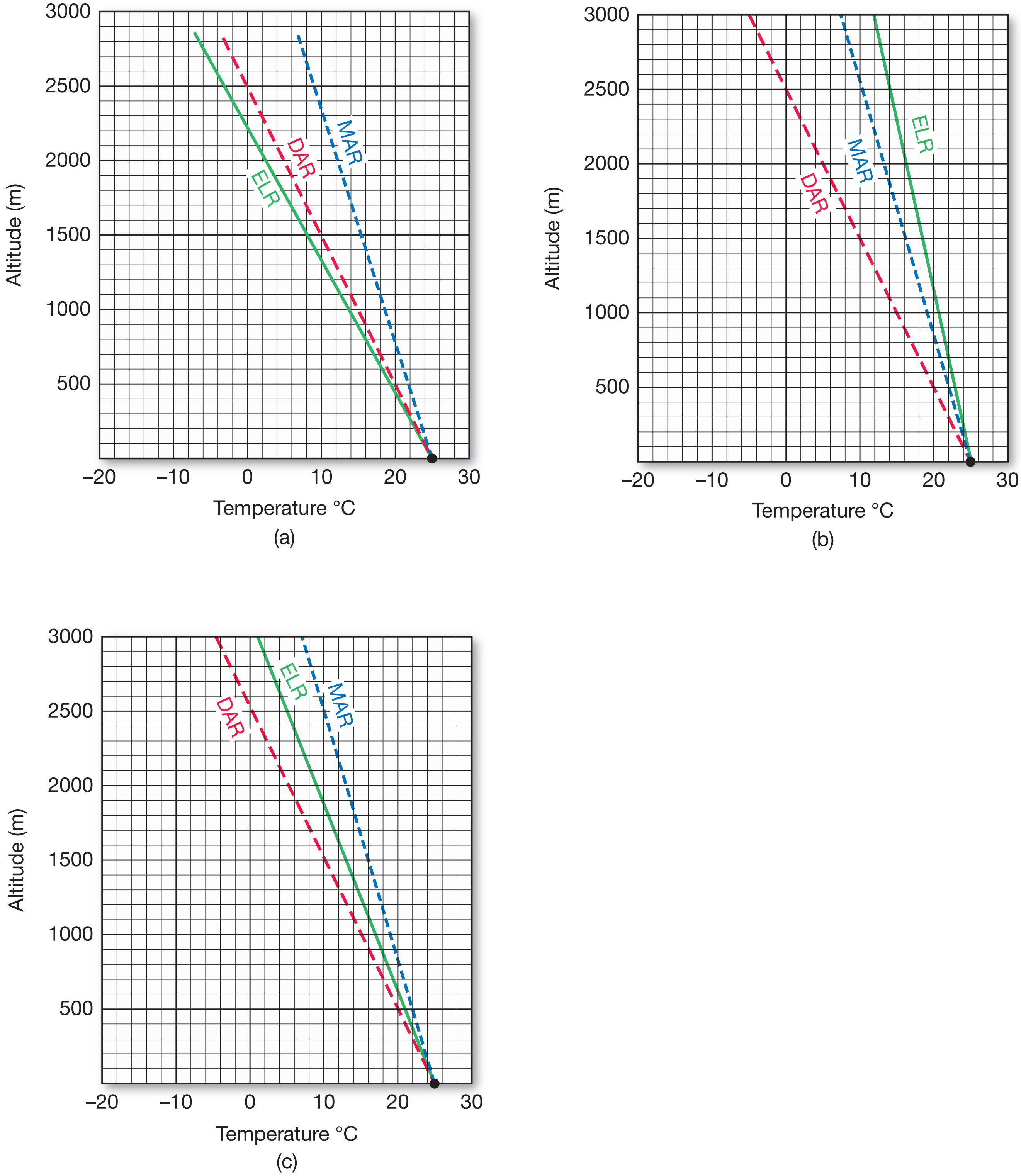
unstable conditions

Stability graph (b)

stable conditions

Stability graph (c)

conditionally unstable conditions



▲ **Figure 13.2** Three atmospheric stability graphs

SECTION 2

Unstable and Conditionally Unstable Atmospheric Conditions

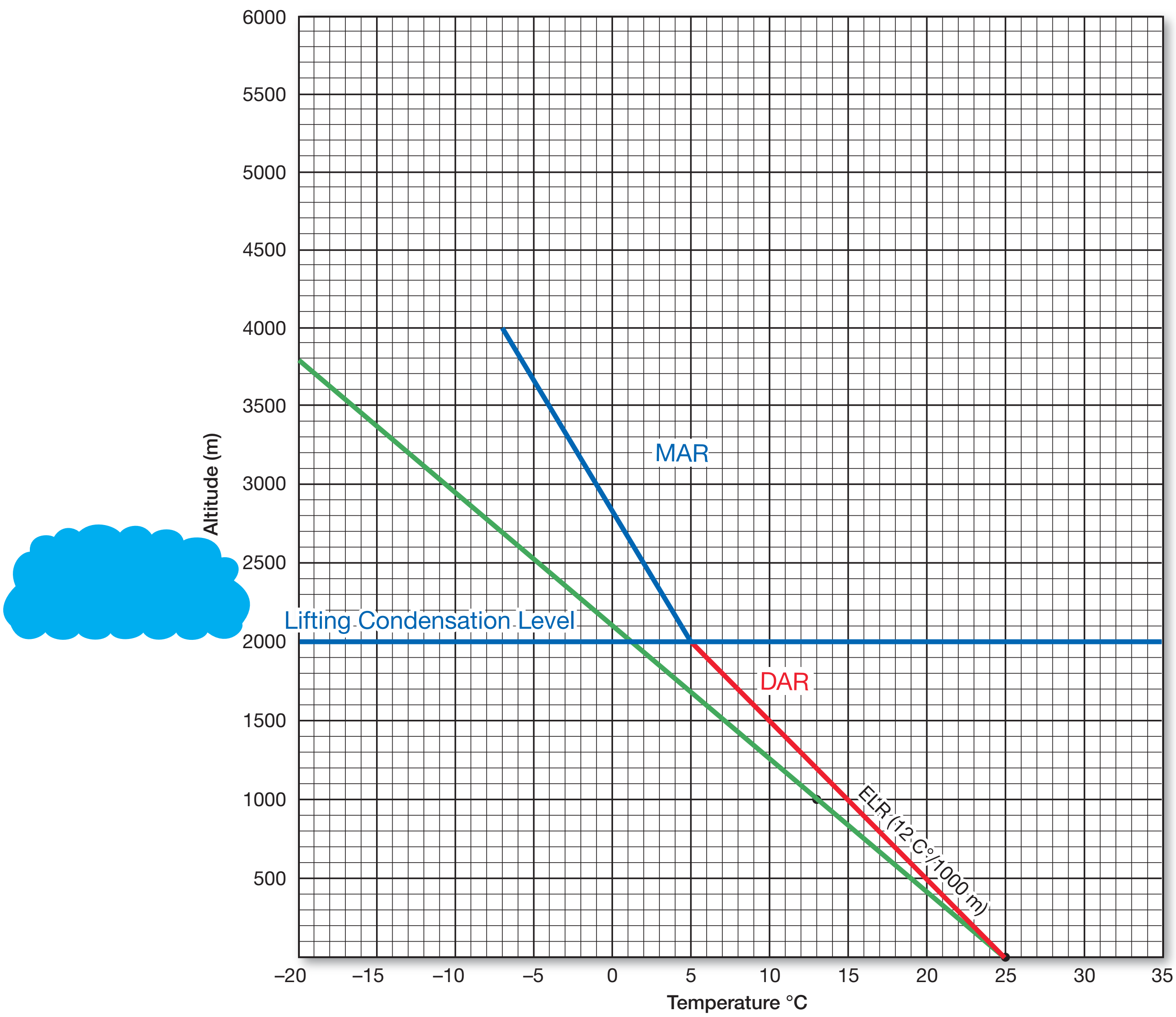
1. Using the graph provided in **Figure 13.4**, plot and label the environmental lapse rate from 1000 m to 3000 m. (Refer to the stability graph you plotted in Figure 13.2a.)

2. What is the dew-point temperature at which the rising air will become saturated? (See Figure 13.3 for maximum specific humidity at various temperatures.)

   5°C

3. How much cooler will the parcel be when it reaches that dew-point temperature?

   20°C



▲ **Figure 13.4** Unstable atmospheric conditions and convective activity

4. Given that the parcel will cool at the DAR until it reaches that dew-point temperature, how many meters will the parcel rise before it cools to the dew-point temperature?

2000 m

5. Plot the DAR on the graph for the lifting parcel of air from the surface until it cools to the dew-point temperature. Draw a horizontal line on the graph at the altitude that the parcel cools to the dew-point temperature and label it as the lifting condensation level.

6. Is the parcel of air stable or unstable at the altitude at which it cooled to the dew-point temperature? At 1000 m? At 2000 m? Explain.

The parcel is unstable the entire time because the ELR is greater than both the DAR and MAR, so the atmosphere is always cooling more rapidly than the parcel.

7. Plot the MAR from the lifting condensation level, the altitude at which the parcel cooled to the dew-point temperature, up to 3000 m.

8. What is the temperature of the parcel at 3000 m? What is the maximum specific humidity at that temperature? What is the difference in specific humidity in grams per kilogram between the parcel when it was on the ground and at 3000 m?

The parcel is −1°C at 3000 m, with a max SH of 3.6 g, which is 1.8 g less than on the ground.

Assume that an air parcel with a specific humidity of 7.6 g/kg and an internal temperature of 30°C begins to lift. Assume an environmental lapse rate of 8 C° for the air surrounding the lifting parcel. Use standard values for the DAR and MAR given in Section 1.

9. Using the graph provided in **Figure 13.5**, plot and label the environmental lapse rate from the surface to 6000 m. (Refer to the stability graph you plotted in Figure 13.2a.)

10. What is the dew-point temperature at which the rising air will become saturated? (See Figure 13.3 for maximum specific humidity at various temperatures.)

10°C

11. How much cooler will the parcel be when it reaches that dew-point temperature?

20°C

12. Given that the parcel will cool at the DAR until it reaches that dew-point temperature, how many meters will the parcel rise before it cools to the dew-point temperature?

2000 m

13. Plot the DAR on the graph for the lifting parcel of air from the surface until it cools to the dew-point temperature. Draw and label a horizontal line on the graph, marking this lifting condensation level.

14. Is the parcel of air stable or unstable at 1000 m? At 2000 m? Explain.

The parcel is stable because it is colder than the air around it.

15. Plot the MAR from the lifting condensation level, the altitude at which the parcel cooled to the dew-point temperature, up to 6000 m.

16. At what altitude did the parcel become unstable? Draw a horizontal line to indicate that altitude and label unstable above that line and stable below it.

Above 4000 m

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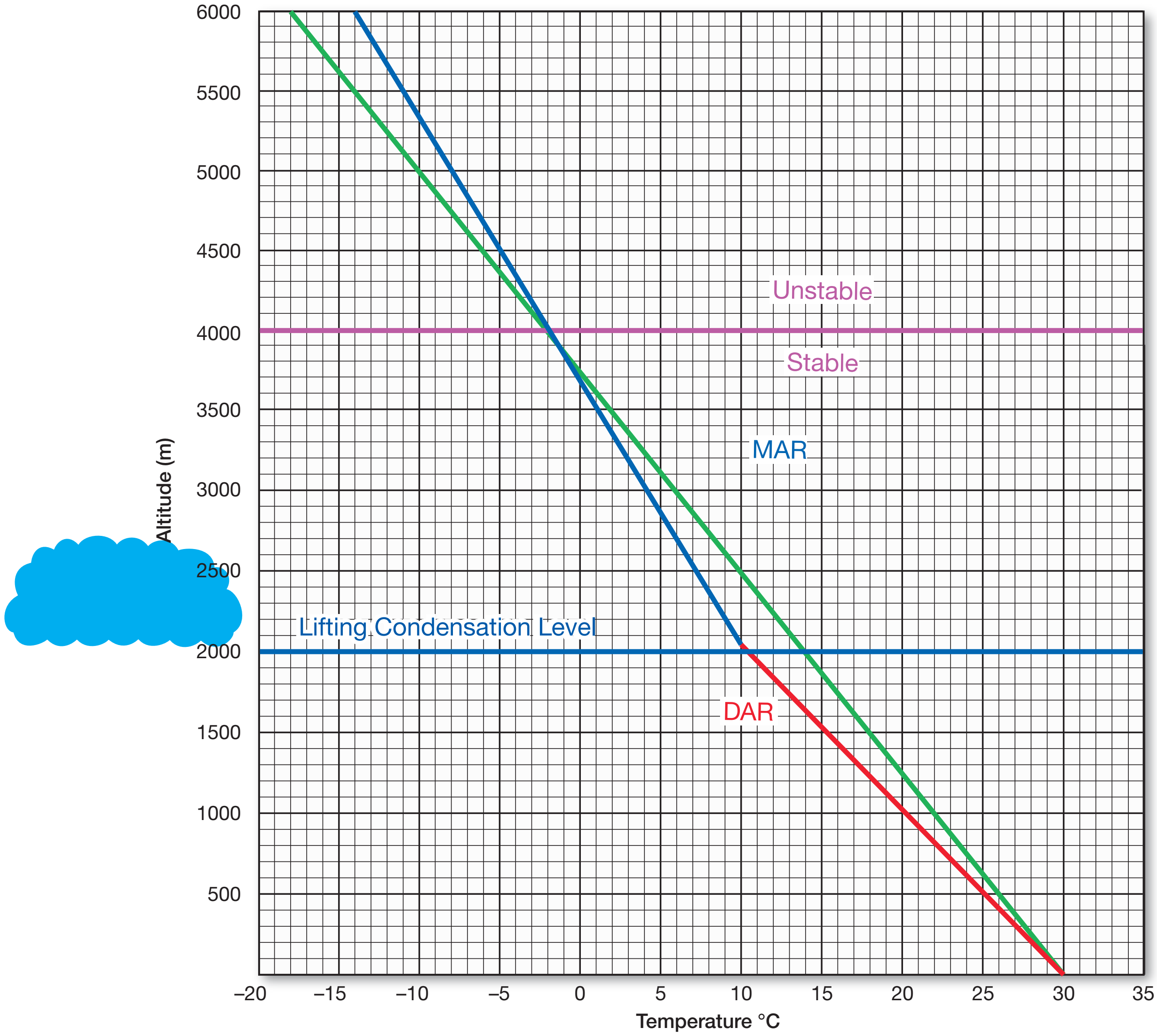


▲ Figure 13.5

17. What is the temperature of the parcel at 6000 m? What is the maximum specific humidity at that temperature? What is the difference in specific humidity in grams per kilogram between the parcel when it was on the ground and at 6000 m? How many grams of water vapor would have condensed from the parcel, in grams per kilogram?

−14, 1.3 g/kg, 6.3 g/kg

18. If the parcel descends, how would its temperature change? How would that affect the parcel's relative humidity? How does this relate to the rain shadow concept?

If the parcel descends, it will heat by compression. As it warms, the relative humidity will decrease, creating a dry rain shadow region.

SECTION 3

Orographic Lifting and Rain Shadows

1. Fill in the answer blanks in Figure 13.6.
2. What is the condensation height for this storm?

   1100 m

3. Do you live on the windward or leeward (rain shadow) side of the nearest major terrain feature? What is the nearest terrain feature that controls your precipitation?

   Personal answers

4. Take a parcel of air from the Bay of Bengal in the Indian Ocean up to Cherrapunji at 1500 m (4900 ft). Assume that its temperature is 30°C and has 90% RH at 0 m (0 ft) over the Bay of Bengal.

   a) What is the parcel's initial SH?

   24.4 g

   b) What is the dew-point temperature of the parcel?

   28°C

   c) What is the parcel's lifting condensation level?

   200 m

   d) What is the parcel's temperature at 1500 m (4900 ft)?

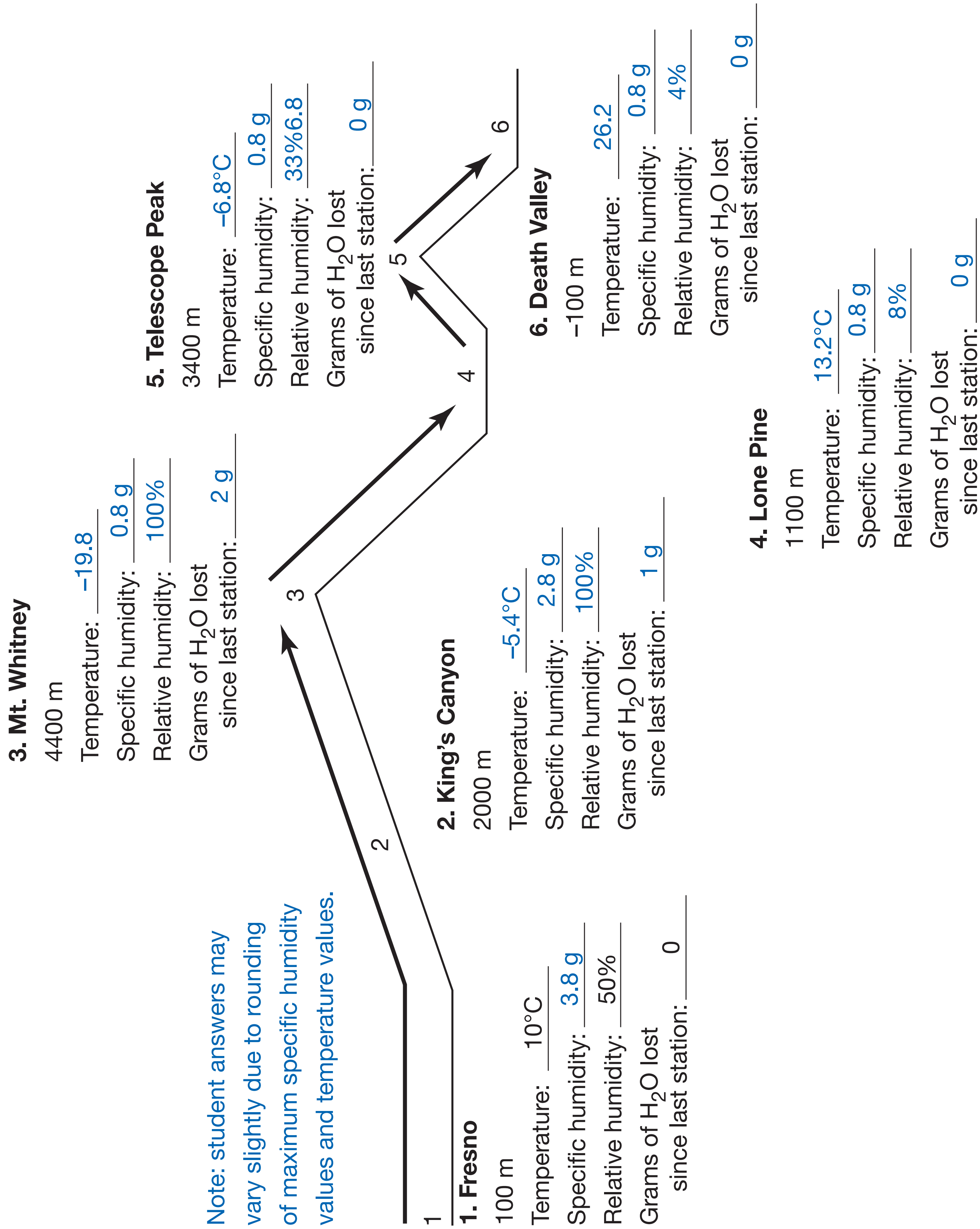
   20.2°C

   e) What is the parcel's SH at 1500 m (4900 ft)?

   14.7 g

   f) How many millimeters of H_2O would fall as rain along the way? (Assume that any moisture in excess of the maximum specific humidity will fall as rain and that 1 g of H_2O is equal to 10 mm of precipitation.)

   97 mm


3. Mt. Whitney
4400 m
Temperature: –19.8
Specific humidity: 0.8 g
Relative humidity: 100%
Grams of H2O lost since last station: 2 g
5. Telescope Peak
3400 m
Temperature: –6.8°C
Specific humidity: 0.8 g
Relative humidity: 33%6.8
Grams of H2O lost since last station: 0 g
6. Death Valley
–100 m
Temperature: 26.2
Specific humidity: 0.8 g
Relative humidity: 4%
Grams of H2O lost since last station: 0 g
2. King's Canyon
2000 m
Temperature: –5.4°C
Specific humidity: 2.8 g
Relative humidity: 100%
Grams of H2O lost since last station: 1 g
4. Lone Pine
1100 m
Temperature: 13.2°C
Specific humidity: 0.8 g
Relative humidity: 8%
Grams of H2O lost since last station: 0 g
1. Fresno
100 m
Temperature: 10°C
Specific humidity: 3.8 g
Relative humidity: 50%
Grams of H2O lost since last station: 0
Note: student answers may vary slightly due to rounding of maximum specific humidity values and temperature values.
1
2
3
4
5
6

▲ Figure 13.6

5. The most rapid temperature increase ever recorded was 27 C° (49 F°) in 2 minutes, recorded at Spearfish, SD, on January 22, 1943, at 7:32 A.M. At 7:30 the temperature was −4°F (−20°C), a downslope Chinook wind brought the temperature up so that 2 minutes later (7:32 A.M.) the temperature was +45°F (+7°C) above zero. How many kilometers would a parcel of air have to sink to raise its temperature by 27 C° (49 F°)?

   2.7 km

6. Take a parcel of air from the top of Mt. Rainier, at 4400 m (14,400 ft), and follow it down to Yakima, Washington, at 300 m (1000 ft). Assume that the initial conditions of the parcel of air are −10°C and 100% RH.

   a) What is the initial specific humidity of the parcel?

   2 g

   b) What will be its temperature, specific humidity, and relative humidity in Yakima?

   33.9°C, SH 2 g/kg, RH 5.8%

   c) How many degrees warmer is the parcel in Yakima than on top of Mt. Rainier?

   43.9°C warmer