Humidity, Condensation, and Clouds

Chapter Four begins by examining the concepts of evaporation, condensation, and saturation. It then looks at the many ways of describing humidity. Here we learn that although relative humidity is the most common way to describe atmospheric moisture, it is also the most misunderstood. After a discussion on relative humidity and human discomfort, we learn that a good indicator of the air's actual water vapor content is the dew-point temperature. The chapter continues with a discussion on the formation of dew, frost, and fog. The end of the chapter describes how clouds are classified. This section helps with the identification of clouds by providing you with many visual clues.

Some important concepts and facts of this chapter:

1. Saturation exists when the number of water molecules evaporating from a liquid equals the number condensing.
2. In our atmosphere, condensation occurs primarily when the air is cooled.
3. Condensation nuclei are important in the atmosphere because they serve as surfaces on which water vapor condenses.
4. The air's actual (water) vapor pressure is an indication of the air's water vapor content.
5. Relative humidity, expressed as a percent, does not tell us how much water vapor is actually in the air, rather it tells us how close the air is to being saturated.
6. The dew-point temperature is a good indicator of the air's water vapor content. High dew points indicate high water vapor content and vice versa.
7. When the air temperature and dew point are close together, the relative humidity is high; when they are far apart, the relative humidity is low.
8. High relative humidities in hot weather can make us feel it is hotter than it actually is by retarding the evaporation of perspiration.
9. Dew, frost, and frozen dew form when objects on the surface cool below the air's dew-point temperature.

10. Fog can form as the air cools, or as water evaporates and mixes with drier air.

11. Clouds are usually divided into four main groups: high, middle, low, and clouds with vertical development.

12. A removable color cloud chart is included in your textbook. Take it out and use it while observing the sky.
Additional Matching (Clouds)

(Some answers may be used more than once.)

1. A “mackerel sky” describes this cloud
   a. cirrus

2. A low, lumpy cloud layer that appears in rows, patches, or rounded masses
   b. cirrostratus

3. A towering cloud that has not fully developed into a thunderstorm
   c. cirrocumulus

4. Hail is usually associated with this cloud type
   d. altostratus

5. The sun or moon are dimly visible or appear watery through this gray, sheetlike cloud
   e. altocumulus

6. A halo around the sun or moon often identifies the presence of this cloud
   f. nimbostratus

7. Wispy, high clouds
   g. stratus

8. Light or moderate but steady precipitation that covers a broad area is most often associated with this cloud
   h. stratocumulus

9. This cloud’s elements (puffs) should be about the size of your thumbnail when your hand is extended to arm’s length
   i. cumulus

10. Lightning and thunder are associated with this cloud
    j. cumulus congestus

11. A cloud of vertical development that resembles a small piece of floating cotton
    k. cumulonimbus

12. A middle cloud that occasionally forms in parallel waves or bands

13. The cloud with the smallest elements or puffs as viewed from the surface

14. A low, uniform, grayish cloud, whose precipitation is most commonly drizzle

15. This cloud’s elements (puffs) should be about the size of your fist when your hand is extended to arm’s length

16. When fog lifts above the surface, it forms this gray, sheet-like cloud

17. Cloud with the greatest vertical growth
Match the Following

1. The maximum pressure that water vapor would exert if the air were saturated  
   a. Heat Index
2. These particles serve as surfaces on which water vapor may condense  
   b. radiation fog
3. When fog "burns off" it does this  
   c. saturation vapor pressure
4. Combines air temperature with relative humidity to determine an apparent temperature  
   d. evaporation-mixing fog
5. Beads of water that have condensed onto objects near the surface  
   e. mammatus
6. Uses wet-bulb and dry-bulb temperatures to obtain relative humidity  
   f. sling psychrometer
7. Fog that most commonly forms on clear nights, with light or calm winds  
   g. evaporates
8. Measures relative humidity with human hairs  
   h. frozen dew
9. A tiny liquid drop of dew that freezes when the air temperature drops below freezing  
   i. wet-bulb temperature
10. Fog that forms when the wind blows relatively warm air over a colder surface  
    j. condensation nuclei
11. These clouds appear as baglike sacks hanging beneath a cloud  
    k. advection fog
12. Fog that forms as moist air flows upward along an elevated surface  
    l. hair hygrometer
13. The lowest temperature that can be obtained by evaporating water into the air  
    m. upslope fog
14. Steam fog and arctic sea smoke are a form of this type of fog  
    n. dew
3. If you are standing outside and notice that the sky is covered with a high, white layered cloud, and you look at the ground and observe your shadow, you may conclude that the cloud overhead is:
   a. altostratus
   b. cirrostratus
   c. stratus
   d. nimbostratus
   e. stratocumulus

4. When the air temperature increases, the saturation vapor pressure:
   a. increases
   b. decreases
   c. does not change

5. If you are interested in the air's water vapor density, then you would be interested in the:
   a. specific humidity
   b. mixing ratio
   c. absolute humidity
   d. relative humidity

6. Of the different types of fog listed below, which one does not necessarily form in air that is cooling?
   a. advection fog
   b. radiation fog
   c. upslope fog
   d. evaporation-mixing fog

7. The highest clouds in our atmosphere are called:
   a. cirrus
   b. altocumulus
   c. noctilucent
   d. cumulonimbus
   e. cumulus congestus

8. Polar air is considered "dry" because the dew-point temperatures are often quite low. However, the relative humidity of this cold, polar air is usually high because:
   a. low dew points indicate that the relative humidity must be high
   b. low air temperatures indicate that the relative humidity must be high
   c. the air temperature and the dew point are fairly close together
Fill in the Blanks

1. The process of water changing from a liquid to a vapor is called _____________.

2. Cirrus clouds are composed primarily of ___________ ___________.

3. ___________ ___________ can be described as the percent of water vapor in the air compared to that required for saturation.

4. The cooling of the ground to produce dew and frost is mainly the result of _______________ cooling.

5. On most days the relative humidity reaches its highest value when the air temperature reaches its _______________ value.

6. Clouds with a lens shape that often form over and downwind of mountains are called _____________ clouds.

7. The temperature to which air must be cooled for saturation to occur is called the _______________ _______________.

8. ____________ forms when water vapor changes directly into ice without becoming a liquid first.

9. A cloudlike stream seen forming behind a jet aircraft is called a(n) _______________.

10. The circulation of water within the atmosphere is called the _______________ cycle.

11. Instruments that measure humidity are called _______________.

Multiple Choice

1. Which is the best indicator of the actual amount of water vapor in the air?
   
   a. air temperature
   b. dew-point temperature
   c. relative humidity
   d. wet-bulb temperature
   e. saturation vapor pressure

2. If the air temperature remains constant, evaporating water into the air will _____ the dew-point temperature and _____ the relative humidity.
   
   a. decrease, decrease
   b. decrease, increase
   c. increase, decrease
   d. increase, increase
True–False

1. The relative humidity is a measure of the air’s actual water vapor content.

2. All other factors being equal, increasing wind speed enhances evaporation.

3. On a hot, humid day, a good measure of how cool the human skin can become is the wet-bulb temperature.

4. Fog can be composed of ice crystals.

5. Dew is more likely to form on clear, windy nights.

6. A cloud that forms in descending air is the mammatatus.

7. Relative humidity is always given as a percent.

8. The process by which water changes from a vapor to a solid is called deposition.

9. In middle latitudes, high clouds are typically observed below an altitude of 20,000 ft or 6000 m.

10. Valleys are more susceptible to radiation fog than are hilltops.

11. Advection fog often forms as warm rain falls into a cold layer of surface air.

12. If you turn on your oven and open its door, the increase in air temperature would raise the relative humidity inside your home.

13. Near the earth’s surface at the same temperature and level in the atmosphere, warm humid air is less dense than warm dry air.

14. When the air is saturated, an increase in air temperature will cause condensation to occur.

15. Another name for “luminous night cloud” is noctilucent cloud.

16. Suppose the air temperature inside your home is 78°F and you lower it to 68°F. As long as the moisture content of the air inside does not change, the relative humidity should increase.

Additional Questions

1. List the two most important factors that cause the relative humidity of air to change.

   a. 

   b. 
9. A cloud that sometimes resembles a silken scarf capping the top of a developing cumulus cloud is the:
   a. nacreous cloud
   b. noctilucent cloud
   c. pileus cloud
   d. mammatus cloud
   e. scud

10. The most common type of fog that forms over the Pacific coastal waters of North America is:
    a. advection fog
    b. radiation fog
    c. evaporation-mixing fog
    d. upslope fog

11. Which of the clouds listed below is least likely to produce precipitation that reaches the ground?
    a. nimbostratus
    b. cumulus congestus
    c. cumulonimbus
    d. stratus
    e. cirrocumulus

12. As the air temperature decreases, the likelihood of condensation occurring:
    a. increases
    b. decreases
    c. does not increase or decrease

13. These clouds form in the stratosphere and are also called mother-of-pearl clouds:
    a. cumulonimbus clouds
    b. noctilucent clouds
    c. nacreous clouds
    d. nimbostratus clouds
    e. pileus clouds

14. Which condition below would best describe supersaturated air:
    a. relative humidity is zero (0) percent.
    b. relative humidity is 50 percent.
    c. relative humidity is 100 percent.
    d. relative humidity is 110 percent.
Additional Questions

1. a. changes in air temperature
   b. changes in water vapor content

2. a. Air Temperature  Saturation Vapor Pressure
   0°C             about 6 millibars
   10°C            about 12 millibars
   20°C            about 23 millibars
   30°C            about 42 millibars

   b. Relative humidity = \( \frac{\text{actual vapor pressure}}{\text{saturation vapor pressure}} \times 100\% \)

   \[ \text{RH} = \frac{21}{42} \times 100\% = 50\% \]

3. a. cumulonimbus
   b. nimbostratus
   c. lenticular
   d. stratocumulus
   e. cirrostratus
   f. cumulus
   g. cirrus
   h. altostratus
   i. cirrocumulus
   j. altocumulus
   k. mammatus

4. a. Air Temperature  Relative Humidity  Apparent Temperature
   80°F              90%               88°F
   90°F              70%               106°F
   100°F             50%               120°F
   110°F             30%               123°F
### Answers

#### Matching

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#### Additional Matching (Clouds)

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1. evaporation
2. ice crystals
3. relative humidity
4. radiational
5. lowest or minimum
6. lenticular
7. dew-point temperature or dew point
8. frost
9. contrail or condensation trail
10. hydrologic
11. hygrometers

#### Multiple Choice

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#### True-False

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