I. Changes of state
   A. oxygen and nitrogen change state at -200\(^\circ\)C, while water changes easily (Fig. 15.2)
   B. importance of latent heat
      1. __________________ - heat released or absorbed during phase change of water
      2. liquid to gas change
         a) 
         b) latent heat of vaporization
         c) when water evaporates, the object cools
d) 
      3. gas to liquid change
         a) 
         b) heat is given off
         c) ex. fog melts snow
d) latent heat of condensation
      4. solid to liquid change
         a) 
         b) heat is absorbed
      5. liquid to solid change
         a) 
         b) latent heat of fusion
c) heat is given off
      6. solid to gas change
         a) 
         b) 
c) heat is absorbed
      7. gas to solid
         a) 
         b) heat is released
c) 
II. Humidity: water vapor in the air
   A. humidity -
   B. saturation - when air is 100\% full of water vapor and can hold no more
      1. when water evaporates it releases(increases) pressure called "vapor pressure"
      2.
   C. specific humidity - mass water vapor/mass of dry and moist air
      1. not affected by changes in press. or temp.
      2. a measure of __________________ in a given mass of air
   D. relative humidity (RH) - actual water vapor/amt. air can hold
1. hot, humid day can have RH of only 30%

E.
1. temp. which air has to cool to reach saturation
2. ex. 35°F, less than 32°F, it's frost
3. not affected by temp.

F. measuring humidity
1.
   a) dry bulb
   b) wet bulb

III. The basis of cloud formation: adiabatic cooling
A. fog and dew vs. cloud formation
   1. need saturation for condensation to occur
   2. need to cool to dewpoint
B. adiabatic temp. change
   1. when air expands, it cools
      a)
   2. when air is compressed it warms
      a)
   3. ______________ - when temp. is changed although no heat is added or subtracted
      a) dry adiabatic rate
         (1) pressure decreases with Z
         (2) so air expands and cools with Z
         (3)
         (4) descending air is heated (ex. lee side of mountain)
      b)
         (1) if air rises enough condensation occurs
         (2) latent heat of condensation
         (3) air will cool at a slower rate after condensation
         (4)
         (5) 5-9°C/1000m depending upon moisture content

IV. Stability of Air
A. when air rises it cools and expands
B. determining stability
   1. environmental temp. change - actual temp. change with Z
   2. stable air
      a)
      b) ex. of temp. decrease with Z
      c) stable air resists vertical movement and cloud formation
      d) most intense stability occurs when temps. increase with Z, ______________
e) inversion occur at sunset, and traps pollutants
f) stable when env. lapse rate < wet adiabatic lapse rate

3. unstable air
   a) bubble of air forced to rise, _____________________________
   b) ex. temp. chart
   c) env. lapse rate > dry adiabatic lapse rate
   d) usually occurs near sfc. on hot sunny days
   e) forms cumulus clouds in summer

4. a) when moist air has env. lapse rate between dry and wet lapse rates
   b) air is stable in dry air, but unstable in moist air
   c) conditional b/c air must be force to rise before it can become unstable

5. stability and daily weather
   a) clouds don't form in stable conditions
   b) if clouds are forced to rise, not very thick
   c) precip. will be light
   d) unstable air produces intense precip.
   e) produces thick cumulus clouds

V. Processes that lift air
   A. when mountains force air to rise
      2. causes lots of precip. on windward side and no precip. on leeward side called “rainshadow effect”
      3.
   B. fronts
      1. separates two air masses
      2.
      3. warm fronts - gentle precip.
      4. occluded fronts
   C. convergence
      1. when air masses flow together
      2. air must rise
      3. Florida peninsula (high temp. low pressure)

VI. Condensation and Cloud Formation
   A. air must be saturated
   B. need ___________ (dust, smoke, salt, etc)
      1. "hygroscopic nuclei" - readily absorbs water ___________
   C. Types of clouds - classified by form/height
      1. 3 forms
         a) cirrus - high, wispy, thin, sheet-like
         b) cumulus - cottonballs, flat base
c) stratus - no individual clouds, low clouds

2. 3 cloud heights (Fig. 15.19)
   a) high clouds (>6000m) prefix = _______
      (1) cirrus - thin, wispy clouds
      (2) cirrostratus - high fluffy clouds
      (3) cirrostratus - high flat layered clouds
      (4) all made of ice crystals
      (5) don't produce precip.
      (6) warn of impending weather
   b) middle clouds (2000-6000m) prefix = ______
      (1) altocumulus - thick globular masses
      (2) altostratus - uniform white/grayish sheet, may have light precip.
   c) low clouds (<2000m) prefix = __________
      (1) stratus - uniform low clouds that cover most of sky, produce light precip.
      (2) stratocumulus - broken globular patches
      (3) nimbostratus - rainy, low clouds and form in stable conditions
   d) clouds of vertical development - clouds that can be in any category
      (1) associated with unstable air
      (2)
      (3) associated with heavy rain

D. Fog - cloud at or near the ground
   1.
   2. most fogs produced by radiational cooling
   3. Fogs caused by cooling
      a) when warm moist moves over a cool surface fog develops called "advection fog"
      b) foggiest place in U.S. is ________________
      c) warm spring winds blow over a snow sfc.
      d) radiation fog - form on clear cool nights, and forms in valleys first, esp. in river valleys
      e) upslope fog - when warm humid air moves up a mountain side and air cools adiabatically
         (1) happens over Great Plains as SE winds usher in warm humid air
   4. evaporation fogs - when air evaporates water off sfc. to produce fog
      a) steam fog - when cool air moves over warm water fog forms which looks like steam, and is
         common in winter over unfrozen lakes/riders
      b) precipitation fog - when rain falls, and evaporates off sfc.

E. How precip. forms
   1. clouds are made up of billions of tiny cloud drops
   2. millions of clouds drops produce one raindrop
   3.
      a)
      b) have large and small drops in clouds
c) larger drops form on larger nuclei (ex. salt)
d) large drops fall much faster than small drops
e)
f) sometimes drops break up when they collide
g) drops of opposite electric charge merge easier
h) amt. of time a drop spends in a cloud is important (cloud thickness)
i) strong updrafts keep the drop in the cloud longer
   (1) stratus clouds have smaller raindrops b/c weaker updrafts
   (2) largest drops fall out first, weaken updraft, then everything falls (ex. thunderstorm)
   (3) 4 significant factors in raindrop production:
      (a) droplet size
      (b) electric charge of the droplet
      (c) cloud thickness
      (d) updrafts of the cloud

4.
   a)
   b) clouds extend above freezing level (cloud diagram)
c) below freezing level collision- coalescence dominates
d)
e)
   (1) many supercooled drop surround large cloud drops and ice crystals
   (2) more water vapor around water drops, so there's a higher vapor pressure
   (3) air flows from high to low pressure
   (4) supercooled drops move from cloud drops to ice crystals and freeze on contact (contact nucleation)
   (5) ice crystals grow rapidly as water drop gets small
   (6) eventually ice crystal get large enough to fall
   (7) ice crystals fall and collide with supercooled drop causing them to freeze (riming)
   (8) ice crystals can also splinter into many pieces acting as nuclei for supercooled drops
   (9) chain reaction occurs producing many ice crystals quickly
   (10) crystals fall and stick together to make a snowflake
   (11) snowflakes fall and may melt until before it reaches the ground
   (12) much of our rain originally falls as snow

VII. Forms of Precip.
   A. rain and drizzle
      1. originate in nimbostratus or cumulonimbus
      2. drizzle are less than 0.5 mm in size

   B. snow
      1. many ice crystal stuck together

   C. sleet and freezing rain
1. warm air is on top of cold air
2.
3.

D. hail
1. hard lumps of ice associate with thunderstorms
2.
3. form in intense updrafts of thunderstorms

E. Rime
1. otherwise know as freezing fog
2. cloud drop freeze on cold surfaces

VIII. Measuring precip.
A. rain-gauge
B. place gauge in open area
C. precip. is measure in inches
D. snow is melted down and water content extracted