**Introduction to Meteorology**

**Homework #3**

**Answers**

**1. Clouds form as air**  rises **, expands and**  cools **until the**

 dew point  **is reached and condensation occurs.**

**2. a) If the atmosphere is “stable”, when we lift a parcel of air, what will**

 **happen?**

 **b) How about if the atmosphere is “unstable”?**

a) It will resist this change and attempt to return to its original position

b) It will tend to continue rising and, if unstable enough, even accelerate

 upward

**3. a) What process occurs in rising air parcels that are cooling at the dry**

**adiabatic lapse rate that causes them to begin to cool at the saturated adiabatic lapse rate?**

 **b) Why is the saturated lapse rate less than the dry rate (~3.3°F/1000 ft vs.**

 **5.5°F/1000 ft)?**

a) Cloud formation

 b) The release of latent heat with condensation slows the rate of cooling

**4. a) To know the stability of the atmosphere we must know both the adiabatic**

**lapse rates and the**  environmental  **lapse rate.**

 **b) How do we determine this lapse rate?**

 **c) Why do we need to know both rates to know if the atmosphere is stable**

 **or not?**

b) By releasing a radiosonde (weather balloon)

 c) Because if rising parcels are colder than their environment they will be

heavier and tend to sink back to their original position (stable) and if the rising parcels are warmer than their environment they will be lighter and continue to rise (unstable)

**5. What types of clouds tend to form in a stable atmosphere?**

Cirrostratus, altostratus, nimbostratus and stratus. Basically, any type of “stratus” (layered) cloud

**6. The atmosphere is “stable” when the environmental lapse rate is small, that**

**is, when there is a**  relatively small difference in temperature  **between the surface air and the air aloft. Therefore, the atmosphere “stabilizes” when the air aloft**  warms  **and/or the surface air**  cools **.**

**7. The most stable type of atmosphere is one in which the temperature**

**actually increases with height. This is called an**  inversion **. When there is large scale sinking in the atmosphere (high pressure systems) this is called a**  subsidence inversion **.**

**8. The atmosphere “destabilizes” when the air aloft**  cools  **and/or the air**

**at the surface**  warms **. Therefore, on a sunny day, the atmosphere will tend to destabilize during the**  afternoon  **[time of day].**

**9. a) What type of instability, in which the environment is stable with respect**

**to rising unsaturated (clear) air but unstable with respect to rising saturated (cloudy) air, occurs commonly in the troposphere?**

 **b) What types of clouds tend to form in this type of atmosphere?**

 **c)** **What is the elevation where these clouds begin to form (cloud base)**

 **called?**

a) conditional instability

 b) clouds with vertical development (cumulus and cumulonimbus)

 c) condensation level

**10. What are the four mechanisms which cause air to rise (to be lifted or**

 **forced upward) and thus are responsible for the formation of most clouds?**

1. Surface heating and free convection

2. Uplift along topography

3. Widespread ascent due to the flowing together (convergence) of

 surface air

4. Uplift along weather fronts

**11. In one of these mechanisms, convection, stability plays an important role.**

**If the atmosphere is stable, the clouds will have little vertical development and**  fair weather cumulus humilis  **clouds will tend to form. If, however, the atmosphere is conditionally unstable**  cumulus congestus  **and, possibly,**  cumulonimbus **clouds will tend to form.**

**12. When moist air is forced upward by a mountain range (e.g. the Sierra**

**Nevada and Cascades along the west coast) there will tend to be considerable rainfall on the**  windward (upwind)  **side as air**  rises **and very little rain, as air**  sinks **on the**  leeward (downwind)  **side. Regions to the leeward side of these ranges are called “** rain shadows **”.**

**13. a) What are the two general methods of precipitation formation?**

 **b) Which is more prevalent in middle and high latitudes and which is more**

 **prevalent in the tropics?**

 **c) Why?**

a), b) Collision-coalescence process – tropics

 Ice crystal (Bergeron) process – middle and high latitudes

 c) Collision-coalescence process occurs only in warm clouds (tops > 5°F)

 which are, generally, only present in the tropics

**14. In the ice-crystal (Bergeron) process,**  ice crystals  **grow at the**

**expense of the surrounding**  supercooled water droplets  **due to a difference in**  vapor pressure  **surrounding them.**

**15. Most rain that falls in middle latitudes, even in summer, even in**

 **thunderstorms, starts as**  snow **.**

**16. What is it called when precipitation falling from a cloud evaporates before**

 **it reaches the ground?**

Virga

**17. Showery (brief and sporadic) precipitation tends to fall from**

 cumuliform (clouds with vertical development)  **clouds whereas continuous precipitation, covering a larger area tends to fall from**

 nimbostratus  **clouds.**

**18. a) Can it snow if the surface temperature is above freezing?**

 **b) Why or why not?**

a) Yes

 b) Precipitation forms as snow in clouds and a snowflake can fall 1000 feet

 before it melts, even if it is above freezing below the cloud.

**19. How do we measure the intensity of snowfall?**

By how much visibility is reduced.

**20. What is the difference between sleet and hail?**

They form by different methods. Hail only falls from thunderstorms, whereas

sleet falls during cold seasons when raindrops fall through a thick layer of cold air near the surface.

**21. Freezing rain forms as rain falls through a thin layer of**  subfreezing air

 **near the surface which causes the drops to become**  supercooled **.**

 **These drops then freeze**  on contact  **when they reach the surface,**

 **forming an**  icy glaze  **.**

**22. a) What is the “average” ratio of snow to rain accumulation (snow water**

**equivalent)?**

 **b) Why is this ratio so much higher in dry and cold regions (e.g. Rocky**

 **Mountains)?**

a) 10 to 1

 b) Crystals (snowflakes) do not stick together. Thus more air between them

 and more total volume.

**23. What is standard (not Doppler) radar used to measure?**

The intensity and location of falling precipitation

**24. Differential**  heating  **of earth’s surface results in horizontal**

 pressure  **differences. It is these differences which generate the horizontal movement of air, which is called**  wind  **, with air moving (being forced) from regions of higher**  pressure  **to regions of lower**  pressure **.**

**25. a) What is an instrument that measures atmospheric (air) pressure**

**called?**

 **b) Which type is most commonly used today?**

 **c) What is the standard pressure measurement utilized in meteorology**

 **today?**

a) barometer

 b) aneroid barometer

 c) millibar

**26. Why is a steady drop in atmospheric pressure frequently associated with**

 **deteriorating (worsening) weather?**

Because it may indicate the approach of a surface low pressure center (cyclone) which is usually associated with rising air, clouds and precipitation.

**27. What are lines connecting points of equal pressure, drawn on a weather**

 **map, called?**

isobars

**28. A warm air column will be associated with**  high  **pressure aloft and a**

**cold air column will be associated with**  low  **pressure aloft. Therefore, on upper-air maps, high pressure tends to be located to the**

 south  **and low pressure to the**  north **.**

**29. a)What are the four forces that influence the wind?**

 **b) Which of these is responsible for *generating* the wind?**

1) Pressure gradient force – b) generates the wind

 2) Coriolis force

 3) Centripetal force

 4) Friction

**30. Why do closely spaced isobars on a weather map indicate high winds?**

Indicative of strong pressure gradient (force)

**31. Coriolis force is due to the**  rotation of the earth **. In the Northern**

 **Hemisphere, this force causes air to turn to the**  right **.**

**32. Geostrophic balance, a balance between**  pressure gradient force **and**

 Coriolis force  **results in wind (geostrophic wind) that blows**

 parallel **to the isobars at a constant speed with lower pressure to the**

 left **and higher pressure to the**  right  **in the Northern Hemisphere**

 **above the friction layer (above ~ 3000 feet).**

**33. An additional force, centripetal force, permits wind (now called gradient**

**wind) to continue to flow in the manner of the geostrophic wind (relative to the isobars).** **This results in**  counterclockwise  **flow around a cyclone (low pressure center) and**  clockwise  **flow around an anticyclone (high pressure center) in the Northern Hemisphere.**

**34. As a result of all this force/balance crap, on upper-level maps in middle**

**latitudes wind direction (flow) is generally**  westerly  **in the Northern Hemisphere and**  westerly  **in the Southern Hemisphere.**

**35. a) What additional force influences the wind at the surface?**

 **b) How does this affect the speed and direction of the wind?**

a) Friction

 b) Slows it down and, as a result, turns it toward low pressure

 **c) As a result, In the Northern Hemisphere (NH) surface winds blow**

 counterclockwise and into **a low pressure center and**

 clockwise and out of **a high pressure center.**

**36. Air flowing in toward a surface low results in a**  convergence **(crowding**

**together) of air molecules at the surface and a**  divergence **(spreading apart) or air at the tropopause which causes air to**  rise **, thus the**

 bad  **weather associated with surface low pressure systems.**

**37. Pressure gradient force in the vertical is balanced by**  gravity **.**

**This balance is called**  hydrostatic balance **. This balance exists most of the time in the atmosphere and limits**  vertical  **motion.**

**38. Wind direction is the direction**  from which the wind is blowing **.**

**39. In the northeastern U.S. the prevailing wind is**  northwest **in**

 **winter and**  southwest **in summer.**

**40. The amount of force exerted by the wind over an area increases as the**

 square **of the wind velocity. Therefore, if the wind velocity doubles, the force it exerts on an object goes up by a factor of**  four **.**