Meteorology 1004
Introduction to Meteorology
Fall, 2001

Solutions to Examination #2
Given Monday, 29 October 2001

BEFORE YOU BEGIN!! Please be sure to read each question CAREFULLY and, if time permits, check your answers. Answer all questions on the pages provided - do not use additional sheets. Be sure to submit your computer form as well as the exam before leaving the room. This exam is worth 100 points.

Part I: Multiple Choice (2 points each) - Indicate the correct answer on the computer form using a #2 pencil.

1. In a pseudo-adiabatic process, the precipitation created through the lifting of air
   a. Evaporates immediately
   b. Falls out of the parcel
   c. Remains with the parcel
   d. Is neglected
   e. None of the above

2. The potential temperature
   a. Depends upon the pressure
   b. Is not a real temperature
   c. Depends upon the relative humidity
   d. Does not change following the motion of an unsaturated parcel
   e. Both a and d

3. Below the lifted condensation level (LCL), the mixing ratio of a parcel rising vertically
   a. Increases with height
   b. Decreases with height
   c. Stays the same
   d. Is equal to the saturation mixing ratio
   e. Both c and d
4. Which of the following does NOT represent a mechanism by which the CAPE can increase?

a. Daytime heating  
b. Increase in low-level moisture  
c. Mid-level cooling  
d. **Decrease in the low-level relative humidity**  
e. None of the above

5. The diameter of a "typical raindrop" is

a. 0.2 micrometers  
b. 2 micrometers  
c. 20 micrometers  
d. **2000 micrometers**  
e. None of the above

6. The so-called "curvature effect"

a. Inhibits the growth of small drops  
b. Enhances the growth of small drops  
c. Is related to surface tension  
d. Does not have an influence in warm clouds  
e. **Both a and c**

7. Cloud condensation nuclei that have an affinity for water vapor (i.e., that are especially effective in providing a surface onto which water vapor can condense) are said to be

a. **Hygroscopic**  
b. Heterogeneous  
c. Homo sapiens  
d. Hydrosopic  
e. Microscopic

8. The Bergeron-Findeisen process requires the presence of

a. Large and small liquid drops  
b. **Liquid drops and ice crystals**  
c. Strong updrafts  
d. High supersaturation  
e. None of the above

9. Low-altitude, layered clouds that produce gentle precipitation over a broad area are called

a. Cumulus  
b. Virga  
c. Altocumulus castellanus  
d. Cirrus  
e. **Nimbostratus**
10. The pressure gradient force vector
   a. Always points from high to low pressure
   b. Always points from high to low temperature
   c. Is proportional to the acceleration of the wind
   d. Is proportional to the velocity of the wind
   e. Both a and c

11. The isobars are packed tightly together where
   a. The pressure gradient is the strongest
   b. The wind speed is the strongest
   c. The pressure changes least rapidly with distance
   d. Both a and b

12. The gradient of pressure on a constant height surface is proportional to
   a. The gradient of temperature on a constant pressure surface
   b. The gradient of height on a constant pressure surface
   c. The gradient of pressure on a constant pressure surface
   d. The gradient of height on a constant potential temperature surface
   e. None of the above

13. The Coriolis and centrifugal forces are called "apparent" or fictitious forces because they
   a. Exist only in an inertial reference frame
   b. Are needed in order to apply Newton's laws in a non-inertial reference frame
   c. Cannot be explained by any known physical principles
   d. Exist only in a non-inertial reference frame
   e. Both b and d.

14. Which of the following properties of an air parcel does the Coriolis force change?
   a. Speed
   b. Temperature
   c. Direction of travel
   d. Speed and direction
   e. Pressure and direction

15. The winds in the base of an upper-level trough are
   a. Geostrophic
   b. Cyclostrophic
   c. Geotripic
   d. Super-geostrophic
   e. Sub-geostrophic

16. The forces involved in gradient wind balance are
   a. Coriolis and centrifugal
   b. Pressure gradient, friction, and centrifugal
   c. Coriolis and friction
   d. Pressure gradient, Coriolis, and friction
   e. None of the above
17. The thickness of a layer of air between two constant pressure surfaces is proportional to
   a. The mean wind speed in the layer
   b. The mean pressure of the layer
   c. The mean temperature of the layer
   d. The mean relative humidity of the layer
   e. The mean potential temperature of the layer

18. The most appropriate wind approximation for application to tornades is
   a. Geotripic
   b. Centrifugal
   c. Cyclotronic
   d. Cyclostrophic
   e. Geostrophic

19. If the layer of the atmosphere from the ground to 2000 ft contains equal amounts of
    convergence and divergence, the vertical velocity at 2000 ft will be
   a. Zero
   b. Strongly upward
   c. Weakly upward
   d. Strongly downward
   e. Weakly downward

20. If all forces acting on an air parcel exactly balance, the parcel will
   a. Remain stationary
   b. Accelerate
   c. Decelerate
   d. Travel in a straight line
   e. None of the above

**Part II: True/False (2 points each) - Indicate the correct answer on the computer form using a #2 pencil.**

21. It is not possible to observe a geostrophic wind at the equator.
   a. True
   b. False

22. The equilibrium level is always above the level of free convection.
   a. True
   b. False

23. All adiabatic processes are reversible.
   a. True
   b. False
24. The saturation vapor pressure over a plane surface of pure water is greater than that over a plane surface of pure ice at the same temperature
   a. True
   b. False

25. Water droplets can remain in a liquid state in clouds at environmental temperatures of -20°C.
   a. True
   b. False

**Part III: Definitions (5 points each) - Provide a short definition for each term in the space provided.**

1. Convective temperature

   The minimum temperature to which surface air must be heated such that a parcel can rise dry adiabatically to its lifted condensation level (in this case, also the level of free convection) without ever being colder than the environment.

2. Kohler curve

   A graph, the abscissa of which is the radius of a drop and the ordinate the saturation ratio, showing the combined solute and curvature effects in the growth of drops.

3. Centripetal acceleration

   The real acceleration that keeps air moving in a circle. It is directed inward, toward the center of rotation, or opposite to the apparent centrifugal force per unit mass.

4. Heterogeneous nucleation

   The process by which water vapor condenses onto small particles, such as dust and clay, usually at relative humidity values below 100%.
**Part IV: Short Answer (10 points each) - Provide a concise answer to each of the questions listed below.**

1. On the thermodynamic diagram pictured on the next page, CLEARLY SHOW YOUR WORK in the following: **WORKED IN CLASS**

   a. Find and label (do not write the numerical value here) the CCL

   b. Find and label (do not write the numerical value here) the LCL

   c. Find and label (do not write the numerical value here) the convective temperature

   d. Shade the CAPE (positive area)

   e. Cross-hatch the CIN (negative area)

2. On the thermodynamic diagram pictured on the next page, assume that the surface moisture increases by advection to produce a surface dew point of 23°C while the surface temperature remains as shown.

   a. If this surface air is lifted by a mountain to 650 mb, what will be its temperature at 650 mb relative to that of the environment? **SHOW YOUR WORK ON THE DIAGRAM**

      The temperature is approximately 8.5°C

   b. How much water vapor condenses during the parcel's ascent? **SHOW YOUR WORK HERE**

      The parcel has approximately 18.5 g/kg of water vapor (i.e., the mixing ratio) at the LCL, and at 650 mb, this has been reduced to approximately 10.5 g/kg. Thus, some 7.5 g/kg have condensed.

   c. Assuming that all of the condensed water falls out of the parcel at 650 mb, what is the temperature of the parcel after it descends back to the ground on the other side of the mountain? **SHOW YOUR WORK ON THE DIAGRAM**

      Following a dry adiabat downward to 1000 mb from a temperature of 8.5°C at 650 mb yields a 1000 mb temperature of approximately 46°C (114°F).
3. Look **CAREFULLY** at the diagram below and assume that point A is located at 50 degrees north latitude and B is located at 45 degrees north latitude. Also, assume that the air density at both locations is equal to 1.2 kg/m$^3$. Note: $\Omega = 7.292 \times 10^{-5}$ s$^{-1}$.

a. Draw the geostrophic wind direction at both points A and B.

The wind vector is directed parallel to the isobars, with low pressure on the left.

b. Compute the geostrophic wind speed at points A and B (SHOW YOUR WORK)

The magnitude of the geostrophic wind is simply $V_g = \frac{1}{\rho f} \frac{\Delta P}{d}$, where $d$ is the distance over which $\Delta P$ is computed using the scale at the bottom of the page. Note that we have neglected the minus sign because we only want the speed. The perpendicular distance across the isobars at point A (bold line with diamonds at the end) is approximately 100 km (see scale at bottom of page), while that at point B is approximately 450 km. The difference in pressure in both cases is 1000 - 980 mb = 20 mb = 2000 Pa. Thus, we can easily compute the geostrophic wind speeds as follows:

\[
V_g (pt A) = \frac{1}{\rho f} \frac{\Delta P}{d} = \frac{1}{(1.2)(2)(7.292 \times 10^{-5} \sin 50)} \frac{2000 Pa}{100,000 m} = 161.81 \text{ m/s.}
\]

\[
V_g (pt B) = \frac{1}{\rho f} \frac{\Delta P}{d} = \frac{1}{(1.2)(2)(7.292 \times 10^{-5} \sin 45)} \frac{2000 Pa}{450,000 m} = 33.07 \text{ m/s.}
\]

c. Are your results in part b consistent with the diagram? Why or why not? BE BRIEF!

The results are consistent with the diagram because stronger winds should occur where the pressure gradient is the strongest, i.e., point A.