Name _____

Science 123A JTerm 2018

Exam 1
January 16, 2018

This exam is given under conditions of the ***Luther College Honor Code***. You are expected to uphold the highest standards of academic integrity, and you are expected to demand the same from fellow students. **If you are aware of dishonest work, you are expected to contact the Honor Council**.

MULTIPLE CHOICE: Each question has a single correct response. Place an "X" through the ONE you believe is correct. Your response will automatically be counted as "wrong" if more than one choice is marked for a given question. Each correct response is worth 2 points. A wrong selection is worth zero points (that is, there is no penalty for guessing). 30 points maximum

1. The relationship between an air parcel's pressure, density, and temperature is called
   (a) the kinetic theory of gases
   (b) the Ideal Gas Law
   (c) radioactive decay
   (d) the Well-Mixed Theory
2. An atmospheric column has a one-meter squared base and a total dry air mass of 10,200 kilograms. The average mixing ratio of the segment between 700 mb and 500 mb is 8 gm per kilogram. The total mass of the water in this segment is:
   (a) 408 gm
   (b) 40.8 kg
   (c) 16.32 kg
   (d) none of the above
3. The resident atmospheric life-times of H_2O and CO_2 are, respectively,
   (a) nine weeks and ten years
   (b) ten years and nine weeks
   (c) nine days and nine days
   (d) nine days and one hundred years
4. If you are at an altitude where the pressure is 700 mb, approximately _____ of the mass of the atmosphere is below you.
   (a) seven tenths
   (b) one third
   (c) one half
   (d) three quarters
5. Which of the following processes represents a phase change?
   (a) evaporation
   (b) photodissociation
   (c) convection
   (d) conduction
6. The horizontal transport of any atmospheric property by the wind is called:
   (a) advection
   (b) radiation
   (c) conduction
   (d) latent heat

7. Considering radiation effects only, the earth's surface should continually warm and the atmosphere should continually cool. This does not happen due to
   (a) the atmosphere absorbing significant shortwave solar radiation
   (b) the changes in the length of the day
   (c) conduction, convection, and latent heat transfer
   (d) both (a) and (c)
8. The earth as a blackbody radiator
   (a) has a radiation curve identical to that of the sun
   (b) emits more energy at night than during the day
   (c) has an emission maximum at a longer wavelength than the wavelength of maximum emission for the sun
   (d) both (b) and (c)
9. The latitude at which there is a yearly balance between incoming and outgoing radiation is about
   (a) 0°
   (b) 23.5°
   (c) 37°
   (d) 66.5°
10. The average surface temperature of the earth would be approximately _____ than the observed average surface temperature if not for the natural greenhouse effect.
   (a) 15°C cooler
   (b) 15°C warmer
   (c) 30°C cooler
   (d) 60°C cooler
11. Cloudy nights tend to have warmer surface temperatures than clear nights because
   (a) clouds radiate energy out to space
   (b) clouds radiate longwave radiation toward the earth
   (c) clouds act to mix warmer air above with the cooler surface air
   (d) clouds conduct enormous amounts of heat to the atmosphere
12. The greatest variation in daily temperature usually occurs:
   (a) at the ground
   (b) about 1500 meters above the ground
   (c) at the level where thermals stop rising
   (d) none of the above
13. Assuming that the night will remain clear, calm, and unsaturated, the predicted minimum temperature is 32°F. Suddenly the wind speed increases and remains gusty throughout the night. The minimum temperature will most likely be:
   (a) about the same as predicted, but will occur earlier in the night
   (b) higher than predicted due to the release of latent heat
   (c) much lower than predicted due to radiational cooling
   (d) higher than predicted due to mixing

14. The wind around a surface high pressure center in the Northern Hemisphere blows

    (a) counterclockwise and outward from the center

    (b) counterclockwise and inward toward the center

    (c) clockwise and outward from the center

    (d) clockwise and inward toward the center

15. A wind that blows at a constant speed parallel to curved isobars or constant height contour lines is called a

    (a) geostrophic wind

    (b) cyclonic wind

    (c) convergent wind

    (d) gradient wind

16. The magnitude of the vertical acceleration in the standard atmosphere is usually very small because the following forces are in balance

    (a) pressure gradient, Coriolis, and friction

    (b) friction and gravity

    (c) vertical pressure gradient and gravity

    (d) pressure gradient, hydrostatic, and friction

17. A sub-geostrophic wind

    (a) occurs as parcels bend around a high pressure ridge

    (b) is always slower in speed than a gradient wind

    (c) have parcels that flow along a straight path below the 500 mb level

    (d) occurs as parcels bend around a low pressure trough

18. For geostrophic wind, increasing the pressure gradient will

    (a) increase the resultant wind speed

    (b) increase the Coriolis deflection

    (c) decrease a parcel's volume

    (d) both (a) and (b)

ESSAY: Provide written responses, on the lined paper, to the required number of questions in this section. 30 points

19. Answer **ONE** of the following. Circle the letter of the question you want me to grade.

    (a) Air parcels A and B both have a volume of 1 liter. Parcel A is at the surface of the earth near the center of Decorah. Parcel B is directly above parcel A at an elevation of 10,000 meters. Compare and contrast the following characteristics of the parcels assuming a standard atmosphere: density, pressure, temperature, mass, and the relative amounts of the constant constituents.

    (b) Identify two important variable constituents of the earth's atmosphere and discuss why their concentration is variable, aspects of their atmospheric residency length, and their role in weather or climate.

20. Answer **ONE** of the following. Circle the letter of the question you want me to grade.

    (a) The earth's atmosphere is said to be a "selective absorber." Explain what that means and discuss the importance this fact plays in the energy budget of the earth.

    (b) In the discussion of the earth's annual energy balance we saw that the earth's surface absorbs approximately 147 units of radiation energy and emits approximately 117 units resulting in a net surplus of 30 units of radiation energy. Yet, the average surface temperature does not warm. It remains constant. What keeps the average surface temperature constant?

21. Answer **ONE** of the following. Circle the letter of the question you want me to grade.

    (a) A low pressure center <u>above</u> the friction layer of the earth's atmosphere and an air parcel located near the low are depicted in Figure 1,

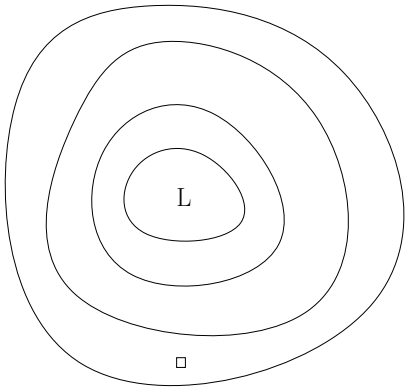

Figure 1: An upper air low pressure center.

    i. Identify all forces acting on the parcel and indicate, on the parcel in the figure, the direction each force would, if acting alone, accelerate the parcel.

    ii. On Figure 1, sketch the path the parcel will take as it moves relative to the low pressure center and explain why the parcel takes this path.

    (b) Scientists theorize that the rotation of the Earth is partly responsible for the breakdown of the single Hadley cell of the one-cell general circulation model, into the three-cell model. If the speed of the Earth's rotation were sufficiently greater, some atmospheric scientists speculate the single cell would break down into five cells. Provide justification for a five-cell model (an odd-number of cells) and not a four or six-cell model (or some even-cell model). Sketch a five-cell model for the northern hemisphere and identify important features such as pressure bands and jet streams.

COMPUTATION: Select **FOUR** questions. Circle the question numbers you want me to grade.

40 points total

22. The average surface temperature for Decorah for January 11 is 20°F. Use the Stefan-Boltzmann formula to determine the total energy, in Joules, that earth's surface will radiate from a one-meter square area over a 24-hour period.

23. The 100 mb surface is located at an elevation of 16000 m in a standard atmosphere, while the surface pressure is 1000 mb. Use the hydrostatic balance equation to determine the average density of the atmosphere between the 1000 and 100 mb surfaces.

24. Suppose all the water vapor in a classroom measuring 10m by 15m by 3m condenses to form water droplets. All the resulting latent heat released warmed the dry air of the room a total of 5 degrees C. Determine how much water vapor condensed if the density of the dry air is 1.2 kg per meter cubed.

25. A dry, two-liter parcel of air at an elevation of 5000 m has a density of 0.6 g/L and a temperature of -25°C.

    (a) Calculate the potential energy of the parcel.

    (b) Suppose the parcel is brought to the surface of the earth and all of the potential energy is converted to thermal energy. Calculate the temperature the parcel would have at the surface of the earth.

26. The geostrophic wind at 5000 meters directly above Decorah is westerly with a speed of 20 meters per second. Point A is directly north of Decorah, and point B is directly south of Decorah. The two points are separated by 500 km. The pressure at 5000 meter above point A is 500mb. Determine the pressure above point B at 5000 meters assuming the density of air at that level is 0.65 gm/L. Decorah is located at 43 degrees north latitude.