EXAM NUMBER _____

NATS 101, Section 4, Spring 2009
Final Exam
May 13, 2009

Name:_____ **SID: S**_____

Instructions:

- **Write your name and student ID on ALL pages of the exam.**
- In the multiple-choice/fill in the blank section, please write-in only **ONE** answer (unless directions state otherwise). **Tear off the multiple exam answer sheet at the end of the exam packet and write your answers on this sheet. Turn this sheet in separately when you hand in your exam.**
- In the short answer section, please make sure to read each question carefully and show your work where it is required. Should you need more room to answer your questions, you can use the other side, and indicate it with the answer.
- You **CANNOT** use a calculator for the short calculation questions.
- You are **NOT** allowed to use your book or notes on this exam.
- You are **NOT** allowed to talk about or look at anyone else's exam. If you commit such an offense, you will be awarded a **0** and the offense will be noted in accordance to **The Code of Academic Integrity**.
- Good luck!

Score:

Multiple Choice Section:	_____/ 40 points
Short Answer Section:	_____/ 25 points
Bonus Questions:	_____/ 10 points
Total:	_____/ 65 points

Helpful constants

Constant in Stefan-Boltzmann law = 5.67×10^{-8} W m^{-2} K^{-4}

Constant in Wien's displacement law = 2900 μm K

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Final Exam
NATS 101, Section 4, Spring 2009
Introduction to Weather and Climate
Multiple Choice, One Word Answer Section

Scoring: Each question is worth 1 point in this section.

1. Which of the following are the two most abundant gasses in the atmosphere?
   a) Neon, Argon
   b) Oxygen, Water Vapor
   c) Nitrogen, Oxygen
   d) Nitrogen, Water Vapor
   e) None of the above

2. Moist air above Lake Erie, which has a surface temperature of 52°F, moves over the city of Erie, Pennsylvania, with has a surface temperature of 34°F. Immediately, fog forms. What type of fog is this?
   a) Upslope fog
   b) Radiation fog
   c) Advection fog
   d) Steam fog
   e) Frontal fog

3. Which type of cloud is indicative of the most instability in the atmosphere?
   a) Cirrus
   b) Lenticular
   c) Fair weather cumulus
   d) Nimbostratus
   e) Cumulus congestus
   f) None of the above because all these clouds occur in a stable atmosphere

4. What is the most severe type of thunderstorm?
   a) Multicell
   b) Squall line
   c) Mesoscale convective complex
   d) Supercell
   e) All of the above are equally severe

5. Carbon dioxide is a trace gas whose levels are increasing annually primarily because of
   a) Vegetative decay
   b) Volcanic eruptions
   c) Animal exhalation
   d) Combustion of fossil fuels
   e) All of the above

6. Mid-latitude cyclones occur on what scale of atmospheric motion?
   a) Microscale
   b) Mesoscale
   c) Synoptic Scale
   d) Global scale

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7. Which of the following changes of state would require the largest input of energy?
   a) Solid to Liquid
   b) Liquid to Vapor
   c) Solid to Vapor
   d) All of the above require the same amount

8. Tornadoes occur on what scale of atmospheric motion?
   a) Microscale
   b) Mesoscale
   c) Synoptic Scale
   d) Global scale

9. In what direction does energy flow in a single cell model of the general circulation?
   a) From the midlatitudes to the poles.
   b) From the poles to the equator.
   c) From the equator to the poles
   d) From the poles to the midlatitudes.
   e) None of the above

10. Studies reveal that during colder glacial periods, CO_2 levels were ___ during warmer interglacial periods.
   a) higher than
   b) lower than
   c) about the same as
   d) more variable than

11. In the mid-latitudes, colder air columns tend to have _____ heights at 500-mb, as opposed to warmer air columns.
   a) Lower.
   b) Higher.
   c) The same.

12. What does Wien's Law indicate?
   a) The hotter an object, the shorter the peak wavelength of the radiation emitted by the object
   b) The total radiation emitted by the Earth
   c) How much of UV radiation is blocked by the atmosphere
   d) Electromagnetic radiation is both a wave and photon particles

13. The terms "global warming" and "the greenhouse effect" refer to basically the same physical process in the atmosphere, and so can thus be used interchangeably. Answer True or False.

14. What is the percentage of incoming solar radiation that is reflected by the Earth's surface and atmosphere back to space? Write your answer as a percentage value.

15. Newton's Second Law of Motion states that
   a) The acceleration that an object experiences is proportional to the net force applied to it.
   b) The acceleration that an object experiences is inversely proportional to the net force applied to it
   c) The acceleration that an object experiences is not proportional to the net force applied to it.
   d) The acceleration that an object experiences is proportionally squared to the net force applied to it.
   e) None of the above

16. The dry adiabatic lapse rate is approximately _____ degrees Celsius per kilometer.

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17. What are the typical weather conditions within a few hundred miles north of a warm front in the northern hemisphere?
    a) Clear and cold. Strong winds from the north to northwest.
    b) Warm and humid with possible thunderstorms. Light winds from the south.
    c) Cool and damp with steady rain and fog. Light to moderate winds from the east.
    d) Heavy snow and possible blizzard conditions. Strong winds from the northeast.
    e) None of the above.

18. In large cities in the southwestern U.S., like Phoenix, the maximum in tropospheric ozone concentration is observed almost always _____ because _____.
    a) in early morning and late afternoon to early evening; that is when the most cars are on the road.
    b) in early morning; the air is not very turbulent so that the ozone will be concentrated near the surface.
    c) in mid to late afternoon; solar radiation is necessary to generate ozone.
    d) in mid to late afternoon; mountain valley circulations direct the ozone toward the urban area.

19. The Hadley cell occurs on what scale of atmospheric motion?
    a) Microscale
    b) Mesoscale
    c) Synoptic Scale
    d) Global scale

20. The primary mechanism that leads to rotation in supercell thunderstorms is
    a) tilting of vortices from the horizontal to vertical orientation
    b) the earth's rotation (Coriolis force)
    c) a clash of different air masses
    d) strong westerly winds

21. In the eye of a hurricane, the air is _____
    a) Rising and warming.
    b) Rising and cooling.
    c) Sinking and warming.
    d) Sinking and cooling.
    e) Neither rising or sinking.

22. The typical wavelength of visible light is ____.
    a) 0.0005 μm
    b) 0.005 μm
    c) 0.05 μm
    d) 0.5 μm
    e) None of the above.

23. An adiabatic process assumes that there is _____ between an air parcel and its surrounding environment.
    a) heat exchanged
    b) no heat exchanged
    c) moisture exchanged
    d) no moisture exchanged

24. Over what regions on Earth are ozone holes located?
    a) All the continents
    b) All the oceans
    c) The tropics
    d) The mid-latitudes
    e) The poles
    f) All of the above

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25. Milankovitch theory suggests that ice ages on the earth could be caused by periodic changes in _____.
    a) The amount of radiation emitted by the sun.
    b) Earth's orbital parameters.
    c) Greenhouse gases.
    d) Volcanic eruptions.
    e) All of the above

26. Extratropical cyclones transport warm air _____ and upward, cold air _____ and downward
    a) to the equator, to the pole
    b) to the west, to the east
    c) to the pole, to the equator
    d) to the ocean, to the continent

27. A typical hot day in Tucson is 100°F. Convert this temperature to °C. Write the numerical answer in the blank for this question.

28. What weather conditions would not be conducive to forming high concentrations of smog over the Phoenix metropolitan area?
    a) Monsoon thunderstorms
    b) A strong subsidence inversion
    c) Light surface winds.
    d) Sunny skies
    e) All of the above are conducive to high concentrations of smog over Phoenix

29. Current global general circulation models (GCMs) most accurately simulate which of the following variables, in comparison to observations?
    a) Precipitation
    b) Sea-Level Pressure
    c) Temperature
    d) Wind Speed
    e) All of the above physical measures simulated by a GCM compare equally well with observations.

30. Turbulent eddies occur on what scale of atmospheric motion?
    a) Microscale
    b) Mesoscale
    c) Synoptic Scale
    d) Global scale

31. The main source of energy for a hurricane is _____.
    a) strong upper-level jet stream winds
    b) strong horizontal temperature differences at the surface
    c) underlying warm ocean and release of latent heat in thunderstorms
    d) ocean currents and tides

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32. Water draining down a sink in the southern hemisphere will _____ because the Coriolis force _____.
    a) Always rotate clockwise; acts to the left of the direction of motion.
    b) Always rotate clockwise; acts to the right of the direction of motion.
    c) Always rotate counterclockwise; acts to the left of the direction of motion.
    d) Always rotate counterclockwise; acts to the right of the direction of motion.
    e) Rotate either counterclockwise or clockwise; is negligible.

33. A hurricane is defined to have sustained winds in excess of _____ mph.

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34. In the southern hemisphere, low pressure systems are called _____ and rotate _____.
    a) Cyclonic; clockwise.
    b) Cyclonic; counterclockwise.
    c) Anticyclonic; clockwise.
    d) Anticyclonic; counterclockwise.

35. If you are driving in your vehicle on the freeway and a tornado is approaching, what is the best course of action to protect your life?
    a) Try to outrun the storm in your vehicle.
    b) Get out of your vehicle and seek shelter under an overpass.
    c) Get out of your vehicle and seek shelter in a low-lying ditch or ravine.
    d) Stop where you are and remain in your vehicle.
    e) You would be equally likely to live or die no matter which of the above actions would be taken.

36. In the three-cell model of the general circulation, areas of surface high pressure should be found at
    a) 30° latitude and the poles.
    b) the equator and 30° latitude.
    c) the equator and 60° latitude.
    d) 30° latitude and 60° latitude.

37. Which is the most accurate description concerning the spatial pattern of observed global temperature increase over the past fifty years or so?
    a) Temperature has increased uniformly everywhere.
    b) Temperature has increased the most in the Arctic.
    c) Temperatures have increased the most in the mid-latitudes.
    d) Temperatures have increased the most in the tropics.
    e) The premise of the question is wrong because global temperatures over the past fifty years or have not exhibited significant increases anywhere.

38. A front is the transition zone between two different
    a) Air pressures
    b) Air masses
    c) Air densities
    d) Areas of precipitation
    e) None of the above

39. In a Chinook wind, what happens to the air after it crosses the continental divide in the Rocky Mountains and descends into the Great Plains?
    a) The air cools by adiabatic expansion.
    b) The air cools by adiabatic compression.
    c) The air warms by adiabatic expansion.
    d) The air warms by adiabatic compression.
    e) None of the above.

40. Extratropical cyclones derive their the majority of their energy from:
    a) Horizontal temperature contrasts, typically between a warm and cold air mass
    b) Warm sea surface, typically where mT air mass forms
    c) Strong winds that occur near mountain ranges
    d) Global warming with additional oscillatory phenomena such as El Niño.

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Final Exam
NATS 101, Section 4, Spring 2009
Introduction to Weather and Climate
Short Answer Section

Scoring: Each question is worth points as indicated.

41. How has the amount of sea ice in the Arctic changed in the last thirty years or so? Physically explain how this change would help to accelerate or mitigate global warming.
(**4 points**)

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42. Suppose in the very near future an Earth-like planet is discovered orbiting around another star in the Milky Way Galaxy. The temperature of the star is 10,000 K. Show your work for full credit in calculations for the first two parts of the question. (**5 points**)

(a) Given that the temperature of our sun is approximately 6000 K, how much more radiant energy per unit area does this star emit compared to our sun?

(b) What is the wavelength of maximum radiation emission of this star?

(c) What is the part of the electromagnetic spectrum that corresponds to the wavelength of maximum radiation emission of the star?

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43. Last week your professor attended a scientific conference in Lund, Sweden. Lund is the province of Skåne, located in the southernmost tip Sweden just west of Denmark as indicated on the map below.

Describe the climate one would experience visiting this part of the world in May. Your description should include mention of the average state and variability of weather conditions in terms of temperature, humidity, precipitation, precipitation type(s), clouds and types of clouds. Where are these types of climates found and why? Is there is place is the United States with a similar climate? If so, where? *Hint: To answer the "why" part of this question, think about the climate of southern Sweden and how it physically relates latitude, its geographic position on the Eurasian continent, and the general circulation of the atmosphere.*
(**5 points**)

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44. How and why are thunderstorms in Arizona that occur during the late summer monsoon season different from those in the eastern and central United States? Describe at least three unique severe weather hazards associated with monsoon thunderstorms. (**5 points**)

45. A sitting U.S. senator was once quoted as saying "Global warming is the greatest hoax ever perpetrated on the American people." Do you agree or disagree with this statement? Give three supporting scientific facts to back up your opinion on this issue. Do not include any political arguments in your discussion. (**6 points**)

BONUS QUESTION #1: List and describe three possible geoengineering solutions that have been proposed to mitigate global warming. What are the advantages and disadvantages of each? (**6 Points Extra Credit**)

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BONUS QUESTION #2: Professor Castro's father, Dr. Anthony E. Castro, worked doing what type of scientific work before he retired from Penn State University in the late 1990s? Why is the type of work he did very important in the context of current global climate and environmental change? *Hint: Dr. Anthony E. Castro was not an atmospheric scientist.*
(**4 Points Extra Credit**)

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Name:_____ SID: S_____

FINAL EXAM ANSWER SHEET
Mark answers TO RIGHT of question number.

Question	Answer	Question	Answer	Question	Answer
1		15		28	
2		16		29	
3		17		30	
4		18		31	
5		19		32	
6		20		33	
7		21		34	
8		22		35	
9		23		36	
10		24		37	
11		25		38	
12		26		39	
13		27		40	
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