Florida Atlantic University
Environmental Issues in Atmospheric and Earth Science
Second Midterm Examination Key

**True-False** - Print the letter T or F in the blank to indicate if each of the following statements is true or false. Illegible answers are wrong. (1 point each)

1. Electromagnetic waves carry energy through a vacuum. (See Archer, p.10) __T__
2. A cold object emits more radiation than a hot object. __F__
3. Light reflected by the earth does not add to the earth’s heat budget. (See Archer, p.20) __T__
4. The earth receives light over half of its area, but radiates over the entire surface. __T__
5. Bonds where dipoles move are less effective at absorbing radiation than those where no dipole exists. __F__
6. Chemical bonds vibrate at particular frequencies. (See Archer, p.30) __T__
7. Air is nearly incompressible, whereas water is highly compressible. __F__
8. For the greenhouse effect to exist, it needs to be colder high in the atmosphere than it is on the ground. __T__
9. The lapse rate for the dry adiabat is greater than for the wet adiabat. (Greater means a larger temperature change per kilometer of altitude.) __T__
10. The real lapse rate over most of the earth is close to the dry lapse rate. __F__
11. Large thunderstorms, tornadoes, and hurricanes derive their energy from the latent heat in water vapor. (See Archer, p.54) __T__
12. Efficiency gains can help reduce agriculture’s dependence on oil. From 1973 to 2005, an impressive decrease of 64 percent occurred in the agricultural use of petroleum. (See plan B 3.0, page 34 - no till agriculture, etc.) __T__
13. Even partial melting of the West Antarctic and Greenland ice sheets will have a dramatic effect on sea level rise. Senior scientists are noting that the IPCC projections of sea level rise during the 21st century of 18 to 59 centimeters are already obsolete and that a rise of 2 meters during this time is within range. (See Plan B 3.0, page 56)

14. As summer neared an end in 2007, reports from Greenland indicated that the flow of glaciers into the sea had accelerated beyond anything glaciologists had thought possible. Huge chunks of ice weighing several billion tons each were breaking off and sliding into the sea, causing minor earthquakes as they did so. (See Plan B 3.0, page 66)

15. In “Survival of Tibetan Glaciers” by James Hansen, the author concludes that Black Carbon from Asian sources is playing an important role in the current rapid melting of the Tibetan glaciers.

16. Lake Chad, in central Africa, the Aral Sea in central Asia, and the Sea of Galilee in Israel are all shrinking and in danger of going completely dry.

17. As a blackbody is heated above 0 K, it begins to emit radiation. The wavelength of the emitted radiation increases as temperature increases.

18. The major gases in the atmosphere, nitrogen, oxygen, and argon, are all greenhouse gases.

19. At equilibrium, the temperature of any body, including earth, is determined by a balance between incoming radiation and outgoing radiation.

20. The earth’s atmosphere shows a linear response to increasing pressure.

21. The temperature of a substance depends on the density of the substance.

22. As temperature increases, so does the vapor pressure of water.

23. Positive feedbacks cause a system to respond so as to increase the amount of change. This process is stabilizing and attempts to maintain homeostasis.

24. Black Soot also has serious adverse health effects.

25. The Hadley circulation keeps the relative humidity below 100% most of the time, with a global average of about 80%
**Multiple-Choice** - Choose the best response to each statement or question. Print the letter corresponding to your choice in the blank. (1 point each)

10   C  1. A burner on an electric stove is turned on high. After a few minutes, it glows bright red. Then it is turned off, and allowed to cool to room temperature. What wavelength of light does it now emit. (See Archer, page13)
   A. It is still glowing red
   B. It does not emit radiation at any wavelength
   C. It emits infrared radiation
   D. It emits ultraviolet radiation

9   C  2. According to Lester Brown, writing in 2007, which of the following statements is true about oil production?
   A. Since 1981, the quantity of new oil discoveries has exceeded the amount of oil extracted by an ever-widening margin.
   B. A bushel of wheat can be traded for a barrel of oil on the world market
   C. World reserves of conventional oil are in a free fall, dropping every year
   D. The twenty-first century will be the oil century, leading an explosive worldwide growth in food production, population, urbanization, and human mobility (Brown wrote this about the twentieth century)

3   D  3. Writing in Plan B 3.0, which of the following does Lester Brown cite as recent evidence of climate change?
   A. Crop-withering heat waves have lowered grain harvests in key food-producing regions in recent years. In 2002, record-high temperatures and drought reduced grain harvests in India, the United States, and Canada, dropping the world harvest 90 million tons, or 5 percent below consumption.
   B. In 2003, the searing heat wave that broke temperature records across Europe claimed more than 52,000 lives in nine countries. Italy alone lost more than 18,000 people, while 14,800 died in France. More than 18 times as many people died in Europe in this heat wave as died during the terrorist attacks on the World Trade Center on September 11, 2001.
   C. Intense heat and drought in the U.S. Corn Belt in 2005 contributed to a world grain shortfall of 34 million tons.
   D. All of the above

12  C  4. In Plan B 3.0, how much does Lester Brown say worldwide water demand has increased in the last half-century? (See Plan B 3.0, page 68)
   A. It has increased by a quarter of the total demand
   B. It has increased by half of the total demand
   C. It has tripled
   D. It has increased by a factor of ten
5. Lester Brown cites international concern over rivers running dry, or aquifers being depleted, in which of the following cases? (See Plan B 3.0, chapter 4)
   A. Israel and the Palestinians
   B. China and countries downstream along the Mekong River, i.e. Cambodia, Laos, Thailand, and Vietnam
   C. Reduced flow along the Tigris and Euphrates Rivers has destroyed 80% of the wetlands, creating conflict between Turkey, Iraq, and Syria
   D. All of the above

6. Inside a greenhouse, the warmed structures and plants inside the greenhouse re-radiate absorbed visible energy as what type of electromagnetic radiation, to which glass is partly opaque?
   A. Microwaves
   B. Infrared
   C. Ultraviolet
   D. All of the above

7. The natural greenhouse effect is due primarily to which of the following gases?
   A. Carbon dioxide
   B. Methane
   C. Nitrous oxide
   D. Water vapor

8. On a per molecule basis, which type of greenhouse gas is the most effective at trapping heat?
   A. Carbon dioxide
   B. Chlorofluorocarbons
   C. Methane
   D. Nitrous oxide

9. What advantage does a computer model have over some type of scientific experiment?
   A. They are much cheaper
   B. They quickly allow conditions to be varied over a wide range
   C. They often suggest where new avenues of research are needed
   D. All of the above

10. Exponential change may be either positive or negative. Which of the following is an example of negative change?
    A. Human population over time from 1850 on
    B. Radioactivity as time goes on
    C. The pressure of earth’s atmosphere as altitude increases
    D. Both B and C
11. A change in the earth’s atmosphere with no change in heat content is called:
   A. Adiabatic
   B. Negative
   C. Positive
   D. All of the above

12. The branch of study concerned with self-regulating systems using communication and control in either mechanical devices or living biological organisms is:
   A. Cybernetics
   B. Homeostasis
   C. Input perturbation
   D. Water vapor feedback

13. Which latitudes are predicted by all the Global Circulation Models to be much more sensitive to climate change than other regions?
   A. High
   B. Temperate
   C. Tropical
   D. Both B and C

14. Which planet currently has a runaway greenhouse effect?
   A. Earth
   B. Mars
   C. Venus
   D. Both A and C
Fill-Ins - Write in the word or words which best completes each statement or answers each question. (1 point per blank)

1. Why is it more convenient to measure the amount of gas by proportion, for example 21% for oxygen, or 394 ppm for carbon dioxide, rather than in concentration, in units of molecules per unit volume?

   GASES CONTRACT AND EXPAND EASILY, WHICH CHANGES CONCENTRATIONS, BUT DOES NOT AFFECT PROPORTION.

2. In the video “On Thin Ice”, shown in class, the scientists found many blue meltwater lakes on the surface of the southern glaciers. 2)Where does the meltwater go? 3) What effect does this have on the glacier?

   2) THE MELTWATER DRAINS THROUGH CREVASSES AND VERTICAL TUNNELS UNTIL IT REACHES THE BEDROCK.

   3) THE WATER UNDER THE GLACIER ACTS AS A LUBRICANT, CUTTING THE FRICTION BETWEEN ICE AND ROCK, AND ALLOWING THE GLACIER TO INCREASE ITS SPEED DRAMATICALLY.

4. The amount of incoming radiation that is reflected back into space is called what, denoted α?

   ALBEDO

5. Scientific models, originally physical but now almost always done on computers, attempt to do what?

   MODELS ATTEMPT TO MIMIC THE BEHAVIOR OF THE NATURAL SYSTEM WE ARE STUDYING

6. The force per unit area applied perpendicular to the surface of an object is called ________.

7. Any process that acts to oppose or amplify changes to a system that is in a steady state is a ________ mechanism.
**Short-Answer Questions** - Write a complete, concise answer to two of the following three questions. Please answer on the following pages, and write the number of the question you are answering in the blank provided. (5 points each)

1. The layer model with no atmosphere produced a temperature colder than the observed average surface temperature of earth. Why? How cold did this model predict the temperature would be? When an atmosphere was added, what was the new predicted temperature? This is still incorrect. Why? Name and briefly describe at least two features which could be added to the model to improve it.

   The bare rock model predicted a temperature of 255K, which is far colder than the observed value of 288K. This model has no greenhouse effect at all. Adding an atmosphere produced a prediction of 303K, which is too warm. A number of problems still exist:
   
   1. All wavelengths treated the same
   2. Concentration of individual greenhouse gases is not used
   3. There are no clouds in the model
   4. There are no aerosol particles

   The model might be improved by adding some or all of the following:
   
   1. Radiation wavelengths might be incorporated in the model
   2. GHG concentrations might be incorporated in the model
   3. The reflectances of clouds might be incorporated in the model
   4. Aerosol particle reflectances might be incorporated in the model
   5. Add more layers, such as a stratosphere with an ozone layer

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2. Methane is a naturally occurring greenhouse gas, which also has considerable human inputs. Relative to carbon dioxide, which has a value of 1, how effective a greenhouse gas is methane? Of what elements is methane composed, and what compounds are these elements converted to when methane is oxidized? What are natural sources of methane? What are manmade sources of methane? What two sources of methane will start to add to the atmospheric load of methane as climate continues to warm?

Methane, on a per molecule basis, is about 21 times as effective a GHG as carbon dioxide. Methane is composed of carbon and hydrogen, which are converted to carbon dioxide and water when methane is oxidized. Natural sources of methane include natural wetlands, termite mounds, the guts of ruminant animals, and slow seepage from fossil fuel deposits, including coal, petroleum, and natural gas. Human sources include artificial wetlands, such as rice paddies, landfills, and much higher rates of release from natural sources due to mining of coal, and extraction of petroleum and natural gas. As climate warms, permafrost melting adds a considerable new source of atmospheric methane from methane deposits frozen into permafrost. In addition, methane clathrates, a frozen combination of methane and water ice, will begin to decompose, possibly releasing large quantities of methane into the atmosphere.
3. Explain what positive and negative feedback mechanisms are. Then discuss how each of the following feedbacks mechanisms works, and, for each case, whether they are positive or negative feedbacks.

- Ice Albedo
- Stefan-Boltzmann
- Water Vapor
- Hydrologic cycle

Feedback is a process whereby some proportion or in general, function, of the output signal of a system is passed (fed back) to the input. Any process that acts to oppose or amplify changes to a system that is in a steady state is a feedback mechanism. Positive feedbacks amplify the change, whereas negative feedbacks oppose change.

The Ice Albedo feedback is positive. Ice has a high reflectivity, or albedo, of about 90%. When ice melts, it is replaced by seawater, with an albedo of about 20%. The seawater absorbs more incoming radiation, raising the heat content, and causing more ice to melt. If the climate is cooling, ice forms, reflecting more radiation and lowering the heat content. The lower heat content allows more ice to form. Either way, Ice Albedo is a positive feedback.

The Stefan-Boltzmann feedback is related to the Stefan-Boltzmann equation for blackbody radiation:

\[ I = \epsilon \sigma T^4 \]

This equation says the intensity of radiation from a blackbody radiator (I) is proportional to the fourth power of the absolute temperature. As temperature increases, the blackbody radiates more intensely, and at shorter wavelengths, which helps to cool the object. Since this feedback opposes the change, it is negative.

Water vapor is a greenhouse gas. As temperature increases, more and more water vapor goes into the atmosphere. This increases the greenhouse effect and helps to raise the temperature further. Thus, water vapor is a positive feedback.

The hydrologic cycle controls the amount of moisture in various regions of earth. If the atmosphere has more water vapor in it, water begins to condense and be removed as rain, snow, etc. This reduces the amount of water in the atmosphere, and lowers water’s contribution to the greenhouse effect. The hydrologic cycle is thus a negative feedback.
Grade Distribution, Midterm 2

Midterm 2 Results

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