

V1003 Science and Society – Prof. deMenocal
Mid-term Exam
March 10, 2004

Instructions: This exam consists of a series of multiple choice and short answer questions. For the short answer questions, please read the questions carefully and please ponder a concise answer before you start answering.

A) Multiple Choice (46 pts total):

1. (4 pts) Which of the following are main cause(s) of Holocene climate variability:
 - a) Solar variability
 - b) Volcanic eruptions
 - c) El Nino
 - d) Earth orbital variations
 - e) All of the above
 - f) a, b, and d

2. (4 pts) How many major biodiversity extinction events have there been over the last 650 million years?
 - a) More than 25
 - b) 12
 - c) 5
 - d) 3
 - e) 1

3. (4 pts) In 1960 there were 3 billion people on the planet and the global population growth rate was around 2.0%, if this persisted unchanged when would you have expected the population to have doubled?
 - a) 2005
 - b) 2000
 - c) 1995
 - d) 1990
 - e) 1980

4. (4 pts) The population doubling time was significantly longer than estimated from the above example. Why?
 - a) The earth's carrying capacity has yet to be reached
 - b) Global death rates were increasing
 - c) Population estimates didn't account for immigration/emigration changes
 - d) Estimates didn't account for technological advances
 - e) Global population growth rates were decreasing

5. (4 pts) A population shift from a late "transitional" to a mature "industrial" stage involves which of the following demographic transitions:
 - a) Stable death rates and decreasing birth rates
 - b) Sharply decreasing death rates and stable birth rates
 - c) Death and birth rates decrease and become roughly equal
 - d) Death and birth rates increase and become roughly equal
 - e) Death rates increase marginally and birth rates decrease

6. (4 pts) Harding's "Tragedy of the Commons" is a particularly instructive example of how people manage common resources. What are the defining characteristics of common pool resources?
 - a) Excludability and subtractability
 - b) Common use and privatization
 - c) Accountability and monitoring
 - d) All of the above
 - e) None of the above

7. (4 pts) Recalling the Stefan-Boltzmann law, if Planet A has twice the surface temperature of Planet B, then:

- a) The emission from Planet A will be twice as great as Planet B
- b) The emission from Planet A will be four times as great as Planet B
- c) The emission from Planet A will be one quarter of that of Planet B
- d) The emission from Planet A will be eight times as great as Planet B
- e) The emission from Planet A will be sixteen times greater as Planet B

8. (4 pts) In the troposphere:

- a) The air temperature increases with increasing elevation because of increased UV absorption by ozone
- b) The air temperature decreases with increasing elevation because air is compressible and the atmosphere is consequently less dense as you move upwards.
- c) The air temperature decreases with increasing elevation because greenhouse gasses like CO₂ absorb UV radiation.
- d) The air temperature increases with increasing elevation because of UV shielding by stratospheric ozone.
- e) The air temperature decreases with increasing elevation because heat is radiated out to space.

9. (4 pts) Economic Interests had the following impacts on the development of international ozone policy?

- a) Led to the creation of the Scientific Assessment Panels
- b) Shaped national proposals for International regulations
- c) Led, at times and when combined with new regulations, to spur innovation.
- d) At times, helped produce support for CFC controls among particular corporations.
- e) A, B and C above.
- f) B, C, and D above
- g) All of the Above
- h) None of the Above

10. (10 pts) Please answer *all* questions True, False, or Insufficient Information. If you say insufficient information, say why (one sentence).

- a) True/False/Insufficient information: The atmospheric lapse rate is 9.8°C/km
- b) True/False/Insufficient information: There would be an ozone hole even if there were no CFC's
- c) True/False/Insufficient information: Ozone depletion resulting from CFCs is greatest during austral spring.
- d) True/False/Insufficient information: The ozone hole is presently about the size of the continental US.
- e) True/False/Insufficient information: About 35% of incoming solar radiation is reflected away.
- f) True/False/Insufficient information: Most UV absorption occurs in the troposphere.
- g) True/False/Insufficient information: The Antarctic ozone hole is larger than the Arctic ozone hole mainly because of the well-developed Antarctic polar vortex.
- h) True/False/Insufficient information: The ozone hole will continue to be a major environmental hazard for many decades.
- i) True/False/Insufficient information: Geostrophic flow results from the balance between pressure gradient and Coriolis forces.
- j) True/False/Insufficient information: Monsoonal circulation mainly develops as a result of the differing heat capacities of the ocean vs. land surface.

B) Graphing or short answer questions (24 points)

11. (5 pts) One a single chart sketch the black-body curves for three bodies: the Sun, the Earth, and Mars (which is 1.5x more distant from the Sun than Earth). Label the x-axis as emission wavelength (0.1 to 1000μm) and label the y-axis as radiation intensity. (Sun, Earth, and Mars temperatures are roughly 6000K, 300K, and 180K; Wein's law is: $L(\mu\text{m}) = 2900/T$).

12. (5 pts) Imagine an idealized Earth-like planet fully covered with water. Sketch (with solid arrows) the surface winds for 30°N to 30°S and also sketch (using dashed arrows) the motion of water as forced by these winds. Label axes please.

13. (5 pts) The Southern Oscillation Index is roughly defined as the Tahiti-Darwin SLP difference. Sketch the SOI for a multiyear period which includes strong El Niño and La Niña condition years. Indicate periods when the eastern equatorial Pacific ocean temperatures were exceptionally warm or cold. Label axes please.

14. (5 pts) Write down the chemical equations for a) natural ozone production and destruction, and b) CFC-related ozone destruction.

15. (4 pts) Why was the African monsoon stronger 9,000 years ago? (in class topic)

C) Short Answer Questions (30 pts total; concise answers please)

16. (10 pts) One of the things we've learned this semester is that the essentially scientific, environmental issues such as ozone depletion or ENSO climate variability are compounded by the separate, very human issue of increasing global population.

- a) Why is global population growth so central to environmental issues?
- b) What is the present world population and pop. growth rate? Where are these headed in coming decades?
- c) What are the leading factors which have led to reduced population growth rates globally?

17. (10 pts) Garrett Hardin's article *The Tragedy of the Commons* raised awareness about our use of the planet's resources and our responsibilities as stewards of these resources. He introduced the principles of common resource management (CRM) as they apply to global environmental problems, noting that "Freedom in a commons brings ruin to all".

Using Hardin's criteria for defining CRM and some of his proposed solutions, discuss how the evolution, discovery, and mitigation of the ozone depletion problem can be viewed within the context of Hardin's "commons" model of CRM. Focus your discussion on the following questions:

- a) Is stratospheric ozone a common resource? Why and/or why not?
- b) How do the concepts of excludability and extractability apply here?
- c) What was the role of technology in "solving" the problem?
- d) In the face of another looming CRM hazard such as global warming (where the threat is less well defined and the solution less apparent), what lessons do you think can we take away from ozone depletion experience?

18. (10 pts) One of the projected consequences of global warming is an invigoration of tropical convection and the Hadley cell.

- a) Why do you think this would happen?

Our present understanding of what will happen to ENSO climate variability in a warmer world is still uncertain, but one set of climate model results suggests that global warming will lead to a greater frequency of La Niña conditions.

- b) Why do you think this would happen? Cite the physical mechanisms and feedbacks that you think would push the tropical Pacific into this mode of variability. Do you think it would stay in this mode for many years? Why/Why not?
- c) Sketch the tropical Pacific ocean and atmosphere changes that would be expected if this occurred. Make sure to indicate changes in sea surface height, SSTs, thermocline depth, upwelling, rainfall, surface winds, and upper level winds.