PUAF 741

Global Environmental Problems

MIDTERM EXAM

Please enter your student number here: _____

You have 90 minutes to complete this exam from the time you remove the staples. The completed exam must be returned to me (in room 4103 VMH) by 9:30 am on Thursday, 21 October. You may also return the exam at 9:15–10:30 am or 12:15–4:00 pm on Wednesday, 20 October. If I am not in my office, push the exam under my office door.

Other than one sheet of notes, you may not consult books, notes, the web, other reference materials, or anyone else's brain in preparing your answers, nor may you assist anyone or communicate the contents of this exam to someone who has not already completed it. Violations will result in failure of the course.

Enter all answers and do your work directly on this exam. If you need more space, use the other side of the sheet.

Partial credit for quantitative questions will be given only if you show your work. Circle or underline final answers. If you need a number you can't find or derive, define a symbol for it or take a guess as to its value and continue. If you don't have time to complete a problem but think you know how to do it, describe the steps. If you think your answer is wrong, indicate this—it's important to know when you don't know.

Qualitative questions should be answered as precisely and succinctly as possible. Complete, polished sentences are not necessary, but your hand-writing must be legible. If I can't read it, I can't grade it!

Exam scores will be posted on the web site early next week. Good luck!

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1. What changes in climate are expected as a result of greenhouse-gas emissions? What changes in climate have been observed? (15 points)

2. Discuss the uncertainties in some of the key climate predictions and observations noted in question 2. (9 points)

3. Briefly enumerate all of the environmental impacts associated with the application of fertilizer. (8 points)

4. A. Roughly how many new passenger vehicles (cars, minivans, SUVs, light trucks) will be sold in the United States this year? (5 points)

B. Average fuel economy of passenger vehicles is about 20 miles per gallon. If this were doubled over the next 10 years, as was proposed by the Bryan Bill, by roughly how much would U.S. carbon emissions be reduced? Gasoline is 30 percent less dense than water, and it chemical composition is roughly $CH_{1.5}$. (15 points)

5. A. The Greenland ice sheet contains 3 million km^3 of grounded ice (ice resting on land). If climate change caused 10 percent of this ice to melt, by about how many feet would mean sea level rise? (7 points)

B. The North Pole ice pack, which is a series of floating ice slabs, contains on average about 20,000 km^3 of ice. If this ice melts, how much will sea level rise? (3 points)

6. A. The preindustrial concentration of CO_2 was 280 ppmv. What was the mass of CO_2 in the preindustrial atmosphere, in gigatons of carbon (GtC)? (7 points)

B. If CO_2 concentration is stabilized at twice the preindustrial value, and the added CO_2 (from fossil-fuel burning and deforestation) has an average residence time of 150 years, what would be the steady-state flow of carbon into the atmosphere, in GtC/yr? (7 points)

C. The current rate of anthropogenic emission is 25 billion metric tons of CO_2 per year. Suppose that parties to the Framework Convention on Climate Change agreed to stabilize global emissions by 2050 at the level calculated in part B. At what average rate would emissions have to decline over the intervening 50-year period? (7 points)

D. Total emissions are the product of population, per-capita GDP, and emissions per unit of GDP. Over the next 50 years, population is expected to grow from 6 to 9 billion, and per-capita GDP is expected to grow at an average rate of 1.5 percent per year.

If global emissions are to be stabilized as described in part C, at what average rate must emissions of carbon per dollar of GDP decline? How does this compare to the average rate of decline over the last 50 years of about 1.2 percent per year? (7 points).

7. As discussed in class, the carbon dioxide concentration has measured each month at a station in Hawaii since 1958.

   A. (5 points) In what month of the year is the concentration:
      Low? High?

      Why?

   B. The difference between the annual high and low concentrations has been increasing steadily since 1958. What does this indicate? (5 pts)

Useful Information

1 meter (m) = 3.281 feet (ft)	1 mole(gas) = 22.4 L @ STP
1 mile (mi) = 1609 m = 5280 ft	1 hour (hr) = 3600 seconds (s)
1 hectare (ha) = 10^4 m^2 = 2.47 acres	1 year (yr) = $3.155 \cdot 10^7$ s
1 m^3 = 1000 liter (L) = 1 te(H_2O)	1 Joule (J) = $kg \cdot m^2/s^2$
1 gallon (gal) = 3.754 L	1 BTU = 1055 J
1 barrel (bbl) = 42 gal	1 kilowatt-hour (kWh) = 3.6 MJ
1 kilogram (kg) = 2.205 pounds (lb)	1 Watt (W) = 1 J/s
1 metric ton (t) = 1000 kg	1 horsepower (hp) = 746 W
1 mole = $6.02 \cdot 10^{23}$ molecules	Kelvin (K) = degrees Celsius (°C) + 273
$M = F \cdot \tau$	$pH = -\log_{10}[H^+]$
$M(t) = M_0 \cdot e^{rt} = M_0 \cdot (1 + i)^t$	$[H^+]$ = moles(H^+) per liter H_2O
$i = [M(t)/M_0]^{1/t} - 1 = e^r$	area of Earth = $5.10 \cdot 10^{14}$ m^2
$r = \log_e[M(t)/M_0]/t = \log_e(1+I)$	mass of atmosphere = $5.14 \cdot 10^{18}$ kg
$\log(a \cdot b) = \log(a) + \log(b)$	moles of dry air = $1.78 \cdot 10^{20}$
$k = 10^3$; $M = 10^6$; $G = 10^9$; $T = 10^{12}$; $P = 10^{15}$; $E = 10^{18}$	
$m = 10^{-3}$; $\mu = 10^{-6}$; $n = 10^{-9}$; $p = 10^{-12}$; $f = 10^{-15}$; $a = 10^{-18}$	
Atomic weights: H = 1; C = 12; N = 14; O = 16; S = 32	