Name:

GEL 134 Final 2007

Part 1. Short Answer

All questions/subquestions in part 1 are worth 2 points. Multi-component questions are broken down into (a), (b), (c), etc and have 2 points per sub-question.

4. What is the approximate flux of solar radiation averaged over the surface of the Earth in watts/m^2 (within 30 percent)?

343 watts/m^2 (240 watts/m^2 accounting for albedo)

5. Most of the light coming into the Earth from the sun has a frequency in the visible range near 600 terahertz. Radiation emitted from a hypothetical Earth (in radiation equilibrium with the sun) has a peak frequency of 25 terahertz. Why the difference (one sentence)?

The earth is much colder, because it only catches a tiny fraction of the total solar flux

8. (a) Approximately how far back in time can ice sheets probe the composition of the Earths atmosphere (within a factor of 2)? **500,000 years**

8. (b) Is the current CO_2 content of the atmosphere within the variation observed in bubbles trapped in the ice sheets? **No, it is higher than anything we have seen in the last 500,000 years.**

8 (c) Is the current CO2 content of the atmosphere higher than at any time in the last 600 million years?

9. (a) How many barrels of oil are used in the US per day (within 20 percent) ?
20,000,000

9. (b) How many barrels of oil does the US produce per day (within 20 percent)?
8,000,000

10. (a) Write down the equation used in a Hubbert-type analysis resource extraction, and note the significance of each term in the equation.

Rate (dQ/dt) = constant x (1-Q/Q_T) x Q

Q is the cumulative production, Q_T is the total amount of the resource, t is time, First term is the initial growth rate, the second term is the amount remaining to be extracted,

10. (b) Contrast this equation with the equation used to describe exponential growth.

Rate (dQ/dt) = constant x Q

10. (c) What is the name of the equation underlying Hubbert's analysis (as we have written it in class)?

It is called the logistic equation

11. How can a Hubbert-type analysis be used to estimate total oil reserves? (Draw a graph). What do you need to know to make the graph?

12. (a) Briefly summarize recent trends in worldwide copper production (one or two sentences) **It is increasing (exponentially (or at least nearly exponentially)**

12. (b) Has recycling/infrastructure saturation made a significant reduction in the worldwide extraction of copper? **No, it continues to increase all the time, new uses are always found**

13. What is the major factor determining the cost of aluminum? (one word or one sentence)

The cost of energy to convert Al-oxide into Al metal.

14. Typical copper concentrations in copper ore are around 10,000 grams/metric ton of ore. Typical platinum concentrations are about 1 gram/metric ton. If copper costs $3.00/lb, give an estimate for the cost of platinum. **30,000 dollars/lb**

15. What is a hectare? **1 ha = a square of land 100 meters on a side.**

16. (a) What units would you use to express soil erosion rates? **tons/ha/year**

16. (b) What are typical soil erosion rates for croplands in Europe and North America (to within 20 percent)? **20 tons/ha/year**

16. (c) What are typical soil erosion rates for croplands in Africa and South America (to within 20 percent)? **40 tons/ha/year**

16. (d) What is a typical rate of soil formation? **1 ton/ha/year**

18. The "green revolution" of the 1950's involved a ten-fold increase in cropland productivity. What was the major technological innovation driving this event?

19. What is the human population of the world (to within 10 percent)?

6.5 billion

20. How much carbon (in gigatons) is stored in the atmosphere (within 20 percent)? **800 GT**

21. How much carbon is consumed every year by photosynthesis (within a factor of 2)? **100-160 GT**

22. What is the residence time of carbon in the atmosphere?

10 years

21. Name two earth materials that are particularly effective in absorbing subsurface contaminants. **Iron and aluminum hydroxides/oxides, clays, humic acids**

22. The global average land surface precipitation runoff is around 50,000 km^3/year. How much of this runoff is withdrawn for human use (within 20 percent)?

5,000 km^3/year, about 10 percent of the total runoff

23. Making predictions about climate change is difficult because the climate is part of a non-linear system. If we want increase the accuracy of our prediction by a factor of two, how much more information to we need to accomplish that?

Approximately 100 times more information (10^2)

28. We used Hubbert's method to estimate oil extraction patterns through time. Does it make sense to substitute "dollars" for "barrels" in this kind of analysis?

Part 2.

What is the role of geology in environmental science? (1-2 paragraphs, may use back of page) (10 points)

Environmental problems are complicated, so it is very hard, if not impossible to make prediction based on the Earth's current state. Geology allows us to determine empirically what the possible states of the Earth's climate have been through time. In the absence of making direct predictions, seeing what kinds of things went on over long time periods are the next best guess to what is possible. Through knowledge of species evolution, geologists can understand what kinds of environmental problems arose in the past and how these were solved (oxygen crisis, species solved this by finding small bugs, mitochondria, to eat oxygen)

Transport of contaminants in the Earth's subsurface depends on the interaction of these contaminants with earth materials such as clays, Al,Fe oxides/oxyhydroxides, and organic acids (humic materials). Study of the behavior of these materials is part of geology.

Geologists are useful for making predictions of stability of structures over long periods of time, for example, predictions of waste disposal scenarios over 20,000 year time scales requires input from geological sciences.

Humans require resources and raw materials. Geologists know where these are found and understand something about extraction history and environmental impacts associated with extraction of resources. They also have some insight into processes associated with resource degradation (water, soil erosion).

Environmental problems may involve geologic hazards such as earthquakes, volcanic activity, flooding. Geologists know how to predict frequencies of these kinds of events.