Mar 28, 2006

Name: ***KEY*** Pledge (sign): ____________________

Env Studies 201 Test #2

Point Total: 100 pts possible

20 pts 1. Pick *four* of the following items, and define each in 1 sentence.

(a) weak sustainability

In weak sustainability, the assumption is that natural and human capital are almost completely interchangeable, so that the depletion of natural resources can be addressed by building human capital (eg by technology).

(b) environmental Kuznets curve

An environmental Kuznets curve describes a trend whereby environmental degradation—such as pollution levels—in a country first increases with increasing wealth, and then decreases as a country becomes industrialized.

(c) common pool resource

A common pool resource is a limited, exhaustible resource that is freely available for use by a large group of people.

(d) POPs

POPs—persistent organic pollutants—are pollutats that are both unreactive and hydrophobic, with environmental lifetimes long enough to spread globally and the ability to bioaccumulate in organisms.

(e) the Haber process

The Haber process is the industrial fixation of nitrogen, whereby elemental forms of nitrogen and hydrogen are combined to form ammonia: $N_2 + 3H_2 \longrightarrow 2NH_3$.

5 pts 2. What key assumption about human behavior is implicit in Hardin's 'tragedy of the commons' and in the Prisoner's Dilemma?

It is assumed that humans behave 'rationally.' In other words, it is assumed that humans behave as motivated by pure self-interest.

5 pts 3. What is Norman Borlaug's main claim to fame?

Borlaug was the head of the Cooperative Wheat Research and Production Program that launched the Green Revolution that increased global food production and helped usher in the era of industrial agriculture. The Green Revolution consisted of the development of high-yield seeds in combination of farming practices, such monoculture planting combined with intensive irrigation and fertilizer use. Monoculture crops usually mandates increased pesticide use as well.

8 pts 4. The authors of *Limits to Growth* state that Earth's natural resources are 'erodable.' What do they mean? What are the consequences of this fact?

When overused, natural resources are depleted. However, when overuse stops it is possible that the resource could recover fairly rapidly to its previous level. For example, a particular pollutant might be rapidly assimilated once it is no longer emitted. Resources that exhibit this kind of behavior lead to the 'overshoot and oscillation' mode of systems response noted in *Limits to Growth*.

But another possibility exists. Natural resources are *erodable* when they can be irreversibly damaged by the depletion caused by unsustainable living. When this occurs, the resource will not recover to previous levels even if pressure on the resource ceases or lessens. It can occur when we significantly overshoot local or global carrying capacities. Examples could include the degradation of ecosystem services caused by excessive depletion of biodiversity, complete collapse of fisheries due to severe overharvesting, or a long-term change in climate due to the emission of greenhouse gases. The potential consequence of resource erosion is a decrease in carrying capacity, followed by societal collapse—particularly if the resource is irreplaceable and global in scope.

8 pts 5. Is the demographic transition most consistent with exponential growth, or logistic growth, or neither? Briefly defend your assertion.

The demographic transition describes (among other things) the population growth that accompanies industrialization of a country. Before industrialization, most countries are characterized by high birth and death rates that are similar in magnitude, meaning that population size is fairly stable but life expectancy is short. The demographic transition that accompanies industrialization occurs in stages: population growth begins when the death rate falls while the birth rate remains high. Eventually birth rates also fall to levels similar to the (now low) death rates. The postindustrial stage of the transition is typically characterized by longer life expectancy and zero population growth, or even a population reduction.

This observed plateau in population is similar to logistic growth—asymptotic approach to the carrying capacity—but not exponential growth. However, there are differences: logistic growth is typically limited by external factors such as resource availability. Population growth ceases after industrialization not because of resource limits but due to social factors.

5 pts 6. (a) What key assumption about human behavior is implicit in Garrett Hardin's 'tragedy of the commons' and in the Prisoner's Dilemma?

Whoops! A failure in quality control (see the answer to question 2).

5 pts (b) What were Hardin's solutions to 'the tragedy of the commons?'

He suggested two solutions: privatization and government regulation. Privatization would convert common pool resources into privately owned resources. Presumably the owner would—behaving rationally—now be motivated to conserve the resource instead of exhausting it (which is what strictly rational behavior would dictate for commons). Government regulation—what Hardin termed 'mutual coercion mutually agreed upon'—would control access to the resource so that, again, it would not be exhausted. According to Hardin, this option would be necessary for commons that could not be privately owned.

8 pts 7. In estimating reserves, petroleum engineers assign a probability to their estimates. Explain the difference between a P90 estimate and a P10 estimate. Which is the larger, more optimistic number?

The P90 estimate is the smaller, more conservative number. There is a 90% probability that the reserve contains *at least* this amount of oil. The P10 estimate is larger and more optimistic, giving a value which has only a 10% chance of being met or exceeded.

8 pts 8. (a) List the main technological challenges in implementing the hydrogen economy; be complete.

The hydrogen economy is an energy system where hydrogen is the main source of energy storage. In order to implement it, we need a method for the efficient, clean and renewable production, distribution, storage and use of hydrogen for energy generation. The main technological challenges to be met are:

- *production* of enough hydrogen in a manner that is renewable and environmentally friendly. We might desire that this production also be decentralized to some extent (ie, distributed generation), which is another aspect to this challenge.
- *storage* of hydrogen in a manner that does not waste too much energy
- creating an infrastructure to *distribute* the hydrogen to end users
- creating cheap *fuel cells* of all sizes to convert the hydrogen to electricity
- creating *automobiles* based on fuel cells that are comparable—in price and performance—to those based on combustion engines

8 pts (b) Donald Anthrop is skeptical about the hydrogen economy. What are his reasons? And what does he recommend?

Anthrop is skeptical for the following reasons:

- The hydrogen economy is not pollution-free; in fact, it may generate even more of some pollutants (carbon dioxide) than a fossil-fuel based energy system.
- Hydrogen production from natural gas is inefficient (and nonrenewable)
- Hydrogen production by coal-generated electrolysis is also inefficient.
- Partly because of these energy inefficiencies, there aren't enough renewable energy sources to power a hydrogen economy.

Anthrop's solution is to let the free market decide on our future, rather than massive government spending on research and other subsidies for technologies related to the hydrogen economy. A free market solution will provide the most efficient solution to meet the challenges of increasing scarcity of fossil fuels (or any other energy source).

8 pts 9. What are Rachel Carson's objections to the use of pesticides in agriculture? List as many as you can; briefly (1 sentence) explain each.

Carson felt that:

- Pesticides had widespread and unintended consequences on ecosystems and human health.
- New pesticides were being developed and used too quickly, without adequate testing or understanding of ecosystem and health effects, and without understanding of their behavior and fate in the environment
- Pesticides were being misused, being applied too widely, too often, and at levels that were too high.
- Pesticide manufacturers both exaggerate the threat of pests and oversell the ability of their product to control that threat.
- Pesticides were not the most effective long-term method of pest control, due to the development of pesticide resistance and ecosystem side-effects.
- The (over)use of pesticides violates a basic human right in that it exposes people to health threats without their knowledge or consent.

12 pts 10. Choose one of the following and answer in detail.

(a) Compare and contrast the concepts of sustainability held by the Club of Rome (authors of *Limits to Growth*) and the Brundtland Commission, authors of *Our Common Future*).

Both groups believed in the concept of a carrying capacity that limits the human population. The Club of Rome stated that carrying capacity limits were set by rates of *sources* of materials and ecosystem services, and *sinks* for pollution that we produce. We cannot use renewable resources faster than they are regenerated, because if we do we will exhaust them. Nonrenewable resources will be eventually exhausted if their use continues; by that time acceptable alternatives must be found. Finally, we cannot generate harmful pollution faster than it can be degraded, absorbed, or otherwise rendered harmless; if we do, then pollution levels will continue to rise and affect both human health and ecosystem goods and services. Basically, sustainable living means living on Nature's *interest* rather than Nature's *capital*. Failure to do so (continued overshoot) will result eventually in societal collapse.

The Brundtland Commission popularized the concept of *sustainable development* which they define as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' They emphasize inter- and intra-generational equity in the distribution of natural resources, while acknowledging—as the Club of Rome did—that all must live within limits imposed by natural resources. The Brundtland Commission believed that economic growth of poor countries was clearly necessary but must be coupled with a respect of resource limits. Overemphasis on either economic growth or environmental protection would doom both efforts: growth must acknowledge and respect the natural world, while protection must not place the needs of the future over those of the poor who are with us now.

(b) Jesse Ausubel asks the question, 'can technology spare the earth?' What does he conclude? Explain how he justifies his position.

Although he doesn't mention it by name, Ausubel implicitly uses the IPAT equation in his analysis. He believes that technology can mitigate increases in population and affluence by using natural resources more efficiently. Largely confining his analysis to the US, Ausubel concludes that annual overall efficiency gains of 2.5 percent is necessary to meet our needs in 2.5 given reasonable projections of population and affluence increases. Ausubel is optimistic about our ability to do so, and bases his optimism on an analysis of the trends of the efficiency of the use of 4 key resources: energy, land for food production, materials, and water.

Ausubel asserts that energy efficiency has been improving over the last several centuries, and presents time series data of the energy efficiency of two important technologies: steam engines (conversion of chemical energy to mechanical energy) and lamps (conversion of electrical energy to light). Improvements would be expected to follow a logistic curve, since efficiency obviously cannot exceed 100%, but Ausubel asserts that *system* efficiency is nowhere near maximum values, and he sees no reason that overall energy efficiency cannot continue to climb rapidly over the next few decades. In terms of energy sources, Ausubel notes the steady 'decarbonization' of our fuels over the last two centuries, a trend that reduces the environmental impact of energy generation and may ultimate conclude with the carbon-less Hydrogen Economy. Thus, Ausubel concludes that energy generation will continue to become more efficient and less damaging to the environment.

Ausubel next looks at land use by examining the effect of technology on agriculture. He presents data from four countries (Ireland, Egypt, India and the US) showing the explosive increases in wheat yields per unit land area in the decades since the Green Revolution. Increasing 'land efficiency' of food production means that more food can be grown by using less land, with corresponding benefits for the preservation of biodiversity. Ausubel thinks that we are nowhere near the ceiling with respect to efficient agricultural productivity, since average yields worldwide lag far below the yields of the most efficient growers. Diffusion of agricultural technologies and practices to close this gap. Ausubel asserts that greater efficiency in areas such as fertilizer use will also occur, reducing the environmental pollution due to intensive agricultural production. Finally, he notes that a switch to a diet with lower meat would further improve the land efficiency of food production, since fewer calories would be required to feed the global population.

In terms of materials use, Ausubel looks at the 'dematerilization' of the US economy by analyzing the trends in the weight of various materials normalized to the GNP. Ausubel notes several cases of dematerialization, such as the increasing replacement of lightweight materials (eg, plastics and aluminum) for heavier ones (eg, steel). Another aspect of dematerialization the increase in the practice of recycling. An ultimate measure of the efficiency of materials use, however, is the amount of municipal solid waste (ie, trash) generated. For the past few decades, per capita trash generation has steadily climbed, although it has not climbed as rapidly as the US GNP. So the evidence of dematerlization is mixed; economic materials efficiency has increased, but overall materials use has climbed in both absolute and per capita terms.

Finally, pPer capita water withdrawals climbed throughout much of the 20th century, but peaked around 1970–1980 and have decreased since. Consumptive uses of water peaked around the same time. Trends of water use per unit GNP are even more favorable: they have been declining since 1940. Noting that other countries are far more efficient in their use of water than the US, Ausubel doesn't believe we are near any ceiling in water use efficiency.