Name: _____   Pledge (sign): _____

Env Studies 201 Test #2 KEY

Point Total: 100 pts possible

8 pts 1. What is the 'IPAT' equation? Briefly: what is its significance in the debate about natural resources?

The equation, $I = P \cdot A \cdot T$, describes how population, P, per-capita consumption level, A, and technological advances, T, interact to influence our impact, I, on natural resources. It is not generally valued for its value in quantitative assessment of environmental degradation so much as its value in describing two major ways that we can deplete natural resources: through overpopulation or through increased affluence.

6 pts 2. (a) Define *sustainable agriculture*.

Sustainable agriculture consists of practices that meet immediate and long-term food production needs while protecting natural resources (eg, by not generating pollution faster than it can be assimilated by the air/water/soil to prevent it from accumulating to toxic levels).

6 pts (b) What is organic farming?

A method of farming that avoids/excludes synthetic pesticides, synthetic fertilizers, growth regulators, and livestock feed additives.

6 pts 3. (a) What are biofuels?

Biofuels are fuels derived from biomass, from recently living organisms (usually plants); an example is bioethanol produced by fermentation of corn. Biofuels are a renewable energy source.

8 pts (b) What are the potential disadvantages of biofuels? List as many as you can.

The disadvantages depend strongly on the source of the biomass and the process used to produce it and the fuel derived from it. They potentially include:

- low net energy yield
- loss of land through conversion to energy crop production; this can increase the price of other goods/services, including food production (leading to higher food prices)
- environmental impacts of agricultural processes used to create energy crops (effects of pesticides on ecosystems and human health, effects on water quality through oxygen depletion, eutrophication, siltation/erosion, loss of fertile soil)
- may release as much or more carbon dioxide as burning fossil fuels
- burning biofuel impacts air quality, though not generally as badly as fossil fuels

10 pts 4. Donald Roberts believes pesticide resistance does not prevent DDT from being an effective control for malaria. What is his reasoning? In your answer, be sure to describe the phenomenon of pesticide resistance.

Pesticide resistance is the phenomenon whereby the target species of a pesticide develops defenses against the pesticide, so that it is progressively less able to kill the pest. It does this through natural selection: the portion of the pest population most resistant to the effects of the pesticide will survive to reproduce. After a number of generations, this trait will become more common and the pesticide will become less effective at killing the pest.

While Roberts acknowledges that mosquitos do develop resistance to the fatal effects of DDT, he argues that DDT does not need to *kill* the mosquitos in order for it to be an effective tool against malaria. He contends that even with pesticide resistance, DDT retains its effects as a spatial *repellant* for the insect, preventing it from spreading malaria.

8 pts 5. (a) What are the defining characteristics of *common pool resources* (CPRs)?

The two defining characteristics are that (i) it is difficult to stop people from using the CPR and (ii) the CPR is subject to overuse; each successive user of the CPR degrades its quality.

12 pts (b) Economists (and environmentalists) point to CPRs as a situation where the free market does not produce an economically efficient outcome; explain what happens and why the free market fails.

Because of the difficulty in excluding users, basically the free market fails to value the CPR properly: the CPR is overused and fails. When a good or service is properly valued, and with certain other assumptions (eg, consumers are properly informed about the value of the good/service), rational (self-serving) behavior of individuals is predicted to lead to optimum economic efficiency, allocating resources in the best possible manner. But a CPR fails precisely because of rational behavior: every potential user has a choice to either use the CPR or not. The consequences can be cast as the Prisoner's Dilemma from game theory:

- if *others* refrain from using the CPR, then the person will gain greatest personal benefit from a decision to use the CPR, contributing slightly to its decline;
- if others decide to use the CPR, it will eventually fail and the person will gain greatest personal benefit by using the CPR while it still exists, again contributing to its decline.

Since all potential users face the same choices, strictly rational behavior seems to lead to a situation where everyone decides to use the CPR and it fails, which is not the optimal (economically efficient) outcome.

12 pts 6. (a) Vaclav Smil does not believe that organic farming is viable as the sole means of food production, maintaining that about one-third of our food production depends on the Haber process. Elaborate: what is the Haber process, what role does it have in food production, and how does it depend on fossil fuels?

The Haber process is the process of combining elemental nitrogen and hydrogen, under conditions of high temperature and pressure, to produce gaseous ammonia: $N_2 + 3H_2 \longrightarrow 2NH_3$. The significance of this process is that it is a form of *nitrogen fixation*, whereby nitrogen—an essential nutrient—is changed from a form (N_2) that is largely unusable to most organisms as a source of nitrogen, to a form (NH_3) from which nitrogen can be assimilated.

Ammonia synthesis is the basis of manufacturer of most synthetic chemical fertilizers. These fertilizers are then used to boost agricultural production, particularly that of the strains developed by the Green Revolution and which form the basis of industrial agriculture.

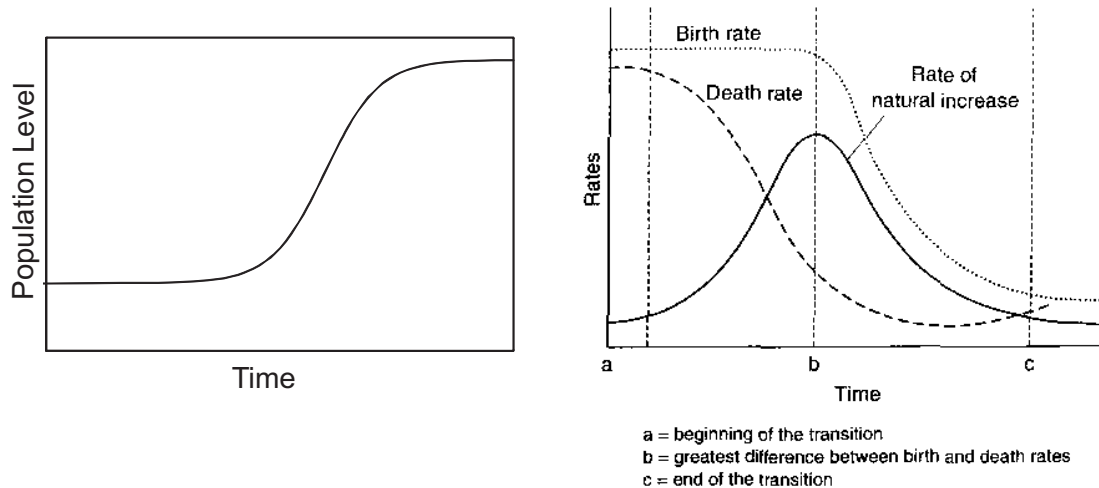Fossil fuels are needed in a number of important ways:
- as the cheapest source of the elemental hydrogen used in the Haber Process (mostly by steam reforming of natural gas);
- to provide the energy for the heat/pressure to increase the yield of the Haber Process; and
- to power the equipment (tractors, etc) used in industrial agriculture.

9 pts (b) What negative environmental impacts are associated with the Haber process? *List them*, as many as you can.

answer
- chemical fertilizers (and crop residues) are a source of nutrient pollution in water that causes eutrophication (oxygen depletion, harmful algae blooms, other ecosystem disruptions) and potential health effects in humans (nitrate/nitrite)
- fertilizer use results in increases in atmospheric nitrous oxide, a by-product of increased global rates of nitrification and denitrification (parts of the nitrogen cycle). This cases slight increases in (a) global warming, and (b) stratospheric ozone depletion
- fossil fuel combustion associated with fertilizer manufacture and application results in major air pollution problems: (a) acid rain, (b) photochemical smog, and (c) PM.

15 pts 7. Two rebuttals commonly used against neo-Malthusians are the existence of *demographic transitions* and *environmental Kuznets curves*. Explain in detail the nature of these two rebuttals; use figures in your explanation. Also describe how a neo-Malthusian would respond to those rebuttals. Use the back of this sheet if necessary.

The demographic transition is a description of what happens to the population of a country as it develops economically, as it changes to a 'first-world' industrial economy. The effect is shown in the figure below

a = beginning of the transition
b = greatest difference between birth and death rates
c = end of the transition

The conventional explanation of the transition is shown in the figure on the right. As the country develops, death rates drop as health care improves; however, the country remains largely agrarian and birth rates remain high. Thus, the population of the country increases dramatically (possibly exponentially). In time, however, the country becomes urbanized, women enter the workforce, and family planning becomes more widespread; the result is that the birthrate falls and the population stops rising. Technologists use this phenomenon to argue that economic growth will not lead to resource depletion due to an exploding human population; the population level will eventually stabilize itself, and without the need for any draconian measures at population control. Neo-Malthusians might respond that we are already past the carrying capacity of the Earth, and even if we are not at present, there is certainly no guarantee that the global population will stabilize at a level where everyone can live at a reasonable level of affluence.

Environmental Kuznets curves (EKCs) result from the observation that as the size of the economy of a country increases, environmental degradation (usually measured as ambient pollution levels) will first increase and then decrease. This shown below.

per capita income
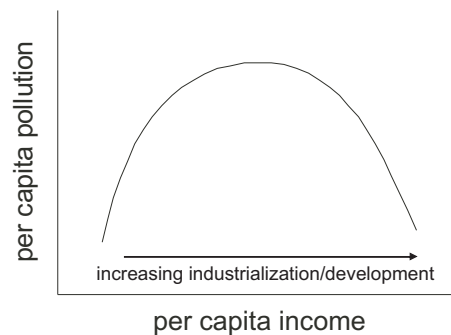
The increase is because initially most resources are devoted to fuel economic growth; but as the average affluence increases, more and more resources will be devoted to environmental protection, reducing pollution levels and other forms of environmental degradation such as deforestation. Technologists again use this phenomenon to argue for economic growth unconstrained by undue environmental regulation. Neo-Malthusians, however, point out that EKCs do not hold for all forms of environmental pollution/degradation; greenhouse gas emissions, for example, have continued to increase with the economy for all countries. Moreover, some countries 'clean up' by essentially exporting pollution, for example by siting dirty manufacturing or extraction processes in other countries.