MID-TERM EXAM

Due: 31 October 2000

This exam is like any other assignment except that it counts for more points and you may not receive help. Take as much time as you like and feel free to refer to books and notes.

1. A. The human population is projected to increase by 50 percent over the next 50 years, from 6 to 9 billion people. What average annual growth rate does this represent?

   B. Today, average income is about $5000 per person. If per-capita income increases at an average rate of 1 percent per year, what will average income be in 2050?

   C. If global annual emissions of a particular pollutant (e.g., carbon dioxide) are to remain constant over this period, at what rate must technological efficiency (emissions per dollar of income) improve?

2. A. A major source of indoor air pollution is the combustion product benzo[a]pyrene (BAP), which is classified by EPA as a probable human carcinogen. In many rural Chinese and Indian villages, coal is burned more or less continuously to boil water. Estimate the concentration of BAP (ng/m^3) in the indoor air, assuming 1 kg of coal per day is burned, that the stove releases 50 mg BAP per kg of coal burned, and that the average residence time of air in a small, two-room hut is about 10 minutes.

   B. The EPA has estimated that the risk of lung cancer death from continuous exposure to BAP is $2 \cdot 10^{-6}$ per μg inhaled. If a person is exposed to the concentration of BAP calculated in part A continuously for 20 years, what would be the resulting risk of lung cancer death? Based on this calculation, do you judge that indoor air pollution is a major health risk in such situations?

3. A economic model predicts that a tax equal to $100 per metric ton of carbon is needed to meet the emission reductions required by the Kyoto Protocol.

   A. Express this tax in dollars per barrel of oil, and as a percent increase over the current price of oil.

   B. Express this tax in cents per kilowatt-hour of coal-fired electricity, and as a percent increase over the current retail price of electricity. Coal-fired power plants are about 35 percent efficient in converting heat to electricity.

4. Mean sea level rose by about 15 centimeters from 1890 to 1990. Possible sources include melting of glaciers and ice sheets, thermal expansion of seawater, and excess withdrawals of groundwater. Estimate the increase due to the latter source. In 1990, global water withdrawals were 3500 cubic kilometers, of which roughly half was from groundwater. From 1940 to 1990, groundwater withdrawals increased at a rate of about 3 percent per year. About 70 percent of withdrawn groundwater is used for agriculture; the remainder is used for domestic and industrial supply.