Part I: Modeling Climate Change (50 minutes maximum time)

Instructions: You may use your computer for this portion of the examination. You can use Stella to plan your model but you must copy your model and your answer onto paper and submit it at the end of this portion of the examination.

Assume that the current level of total greenhouse gases in the atmosphere in tonnes of CO2 equivalents is 4000 billion tonnes which represents 400 parts per million in the atmosphere. By comparison, the pre-industrial level was approximately 200 parts per million. In 2012 humans contributed 30 billion tonnes of CO2 equivalent during the year by burning fossil fuels and other activities. It is projected that if humans continue to behave as they have in the recent past, they will increase their annual emissions by 2.5% each year.

Each year atmospheric CO2 is naturally sequestered in plants and ocean sediments. The amount of sequestration is fairly constant but does increase somewhat as the concentration of atmospheric CO2 rises. The amount of sequestration expected is 10 billion tonnes per year, plus .005 (.5%) of the total atmospheric CO2.

Policy makers hope to reduce emissions to a level at which atmospheric CO2 is stabilized.

1. Describe and draw a Stella-type model that would simulate this very simplified case.
2. Label each element in the diagram.
3. Show the initial conditions, the values and the equations that you would enter into each element of the model.
4. Identify two control variables in this model that policy makers could influence to bring about their policy goals.
5. Suggest and describe two policy strategies for reducing the rate of greenhouse gas emissions that could be tested or illustrated with this model.

Part II: Short answer questions (note that elaborate introductions to your answer, including repetition of the question are not needed and should be avoided). Answer any 6 of the following questions. (50 minutes maximum time)

1. Explain how energy consumption and economic growth are related, and why this relationship differs among countries. What does energy intensity refer to in this context?
	1. *Growth increases income and energy is a normal good. Thus demand rises roughly proportionally to income.*
	2. *In energy exporting countries rising demand for energy leads to economic growth*
	3. *Development requires investment in infrastructure which means that rapidly developing countries require more energy.*
	4. *Different climates, geographies, cultures, and industries lead to different energy intensities*
	5. *Energy intensity is the level of energy required per unit of GDP.*
2. Distinguish between positive and negative feedback processes. How do they affect the dynamics of systems? Give an example of each.
3. *Feedback processes are changes that return to the original sources of the change, thus A affects, B which affects C, which affects A.*
4. *Positive feedback processes amplify the original change.*
5. *Negative feedback processes offset the original change leading to stability, or oscillations.*
6. *Positive: investment-income-investment; population-births-population*
7. *Negative: price-supply-demand-price; a thermostat process*
8. Price, income and cross-price elasticities of demand for energy tell us much about how the demand for energy will change over time. How, and why, do price elasticities change from short to long run, and why do price elasticities differ in one country compared to another? Give two examples of goods that are complements of energy, and two examples of good that are competitive with energy.
9. *In the short-run responses to price change are limited and absolute values of price elasticities for energy are small.*
10. *In the long-run people can invest in energy-saving technology or change behavior (life style, location, job) and change energy more. Price elasticity is greater.*
11. *Price elasticities vary because of geography, culture, economic structure.*
12. *Energy complements: automobiles, tourism, imported foods*
13. *Energy substitutes: telecommunication, public transit, home recreation*
14. Define a user cost and distinguish it from an external cost. Under what circumstances are user costs under-valued or completely ignored by resource users?
15. *A user cost is the present value of future costs caused by current consumption.*
16. *It reflects the future value and scarcity of non-renewable resources*
17. *Includes the future extraction costs of non-renewable resources*
18. *Includes the reduced future productivity of renewable but destructible resources*
19. *Differs from external costs because external costs or current costs borne by others*
20. *User costs are under-valued by those with high discount rates*
21. *User costs are under-valued by those who extract common property resources.*
22. Define a Pareto optimum and list the three conditions that must hold (assuming a perfect market) to assure that a Pareto optimum has been achieved.
23. *Pareto optimum is an economic situation in which no one can be made better off without making at least one person worse off.*
24. *First condition: Consumers choose goods that maximize their utility given prices and income*
25. *Second condition: Producers use mix of inputs that maximize their profit given prices of inputs*
26. *Third condition: Producers produce the mix of goods that consumers demand.*
27. Define the social discount rate, and describe how it is used in benefit cost analysis. How is the discount rate related to opportunity cost?
28. *Society’s rate of time preference*
29. *Social opportunity cost of consuming today relative to the future*
30. *Social discount rate is used to discount future costs and benefits to calculate the present value of net benefits.*
31. *Discount rate reflects the future opportunity cost of consuming now.*
32. Describe the steps required to conduct a sound benefit cost analysis.
33. *Determine the accounting stance (who should be included in the benefits and costs)*
34. *Decide on a social discount rate*
35. *Measure all market, and non-market, direct and indirect costs and benefits using willingness-to-pay concepts. Costs should include opportunity costs of investments made impossible by the project being analyzed.*
36. *Discount all future costs and benefits*
37. *Form a ratio of benefits over costs OR calculate the present value of net benefits*
38. *Choose that project or projects that maximize the present value of net benefits.*