ENVIRONMENTAL SCIENCE
SECTION II
Time—90 minutes
NO CALCULATORS MAY BE USED ON THIS EXAMINATION
4 Questions

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in the pink booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Answer the questions below regarding the heating of a house in the Midwestern United States. Assume the following.
   - The house has 2,000 square feet of living space.
   - 80,000 BTUs of heat per square foot are required to heat the house for the winter.
   - Natural gas is available at a cost of $5.00 per thousand cubic feet.
   - One cubic foot of natural gas supplies 1,000 BTUs of heat energy.
   - The furnace in the house is 80 percent efficient.

   (a) Calculate the following, showing all the steps of your calculations, including units.
      (i) The number of cubic feet of natural gas required to heat the house for one winter
      (ii) The cost of heating the house for one winter

   (b) Identify and describe three actions the residents of the house could take to conserve heat energy and lower the cost of heating the house.

   (c) The residents decide to supplement the heating of the house by using a wood-burning stove. Discuss two environmental impacts, one positive and one negative, of using the wood-burning stove.

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Question 1

1. (a) Maximum 4 points total for (i) and (ii)

(i) **1 point** for correct setup (MUST include units)
1 point for correct answer (units not needed/ignore incorrect units)

(2,000 ft^2) (80,000 BTU/ft^2) (1 ft^3/1000 BTU) = <u>160,000</u> ft^3 natural gas

Note: if 80% is calculated in part (i), then

.8 x = 160,000 ft^3 and correct answer = <u>200,000</u> ft^3 natural gas

OR

.8 x = 80,000 BTU/ft^2, x = 100,000 BTU/ft^2,
therefore (2,000 ft^2) (100,000 BTU/ft^2) (1 ft^3/1000 BTU) = <u>200,000</u> ft^3

OR

(2000 ft^2) (80,000 BTU/ft^2) (1 ft^3/1000 BTU) (1 BTU (in)/0.8 BTU (out) = <u>200,000</u> ft^2

(ii) **1 point** for correct setup (MUST include units) <u>and</u> answer

(160,000 ft^3) ($5.00/1000 ft^3) = <u>$800</u>

OR

(200,000 ft^3) ($5.00/1000 ft^3) = <u>$1000</u>

OR

.8 x = $800, therefore x = $1000

1 point for including the 80% calculation correctly in either part (i) or part (ii).

Note: if answer in part (i) is incorrect, yet calculations in part (ii) are done correctly using the answer in part (i), then the point for part (ii) is awarded.

Question 1 (cont.)

1. (b) Maximum 3 points

Must **identify** action and **describe**.

- Use first three (3) responses given
- Responses must be tied to this house
- No credit for woodburning stove since it is given in part "c" unless it includes a more detailed description

Examples of appropriate action and description:

- Add thicker insulation or higher R-value insulation or "superinsulation"
- Add insulation to attic, exterior walls, ducts, or areas currently not insulated
- Install double, triple, low-E (low emissivity), or storm windows
- Cover exterior windows with plastic
- Caulk, seal, weather-strip around windows and doors, repair windows to seal leaks
- Lock/close windows and doors
- Use solar heating with a specific example
- Place windows on southern, eastern, and western exposures
- Open shades/blinds during the day and close at night
- Lower (turn off) thermostat during the day when no one is home
- Lower thermostat and wear layers of clothing and blankets
- Lower thermostat to remain a few degrees cooler to use less energy and save money
- Add carpet to improve insulation
- Install programmable thermostat (must give specific heat conserving use)
- Close off unused rooms/areas
- Install a higher efficiency furnace
- Install ceiling fan to more evenly distribute heat
- Install stone flooring/adobe or brick walls/trombe wall to absorb heat/redirect/act as a heat sink
- Plant windbreak or shelterbreak to guide wind over and around building
- Add straw bales between walls or outside exterior walls
- Install woodburning stove (fireplace) with additional vents for heat distribution
- Install darker roof tiles
- Change to darker exterior wall color
- Take thermal picture, IR picture to identify leaks
- Maintain furnace/change filters regularly
- Use residual heat from clothes dryer/oven
- Install insulation behind wall outlets/light switches
- Remove/avoid planting trees near south windows

Question 1 (cont.)

1. (c) Maximum 4 points

Positive Impact	**1 point**	Consequence	**1 point**
Negative Impact	**1 point**	Consequence	**1 point**

Note:

- Use first positive and first negative given
- Discussion of other fossil fuels not appropriate
- Impact and consequence must be linked
- Some students may begin their discussion with consequences and receive a consequence point without the impact point

Positive Impact	**Examples of Appropriate Consequences**
Uses renewable resource as opposed to nonrenewable resource Burning new carbon vs. old carbon Use of local vs. transported fuel Burning wood conserves natural gas (fossil fuels)	Specific impact of reduced extraction/processing transport of natural gas reduce pollutant infiltration to groundwater less subsidence less habitat loss (pipelines) reduces methane leaks from pipeline
Ash residue used as fertilizer	Returns nutrients to the soil
Negative Impact	**Examples of Appropriate Consequences**
CO_2 released leading to global warming	Specific impact of increased global warming shifting agricultural areas, change in sea level, shifting biomes, weather extremes, loss of habitat
CO released leading to increased indoor air pollution	Specific impact of CO poisoning: CO binds with hemoglobin, unconsciousness, asphyxiation
Nitrogen Oxides released leading to acid deposition, photochemical smog	Specific impact of increased nitrogen oxides adverse effects on trees, soils, aquatic life in lakes, respiratory problems
Particulates (ash) released leading to air pollution	Specific impact of increased air pollution increased respiratory problems, reduced visibility
Wood (trees) used non-sustainably or larger amounts of wood needed to produce same number of BTUs leading to deforestation	Specific impact of deforestation habitat loss, soil erosion, increased CO_2 levels, decreased biodiversity, desertification, interruption of nutrient cycles