

**AP[®] ENVIRONMENTAL SCIENCE
2007 SCORING GUIDELINES**

Question 2

The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of \$0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

(a) Calculate the following. Be sure to show all your work and include units with your answers.

(i) The total amount of water that the family uses per year for taking showers (2 points—1 point for correct set-up and 1 point for correct answer with units)

10 minutes/day x 5 gallons/minute x 365 days/year x 4 (people) = 73,000 gallons/year
(73,000 gallons also acceptable due to usage defined as per year)

(ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater (2 points—1 point for correct set-up and 1 point for correct answer with units)

73,000 gallons/year ÷ 2 = 36,500 gallons of hot water per year

36,500 gallons/year x 0.20 kWh/gallon x \$0.10/kWh = \$730/year
(\$730 also acceptable due to cost defined as per annum)

(b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs \$1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the \$1,000 initial cost? (2 points—1 point for correct set-up and 1 point for correct answer with units)

Old bill for electricity = \$730/year = \$2/day (\$730/yr ÷ 365day/year = \$2/day)

New bill for electricity = \$730 ÷ 2 = \$365/year
\$365/yr ÷ 365 day/year = \$1/day = new cost per day

Old cost = \$2/day, new cost = \$1/day

Savings old – new = \$1/day

Days to pay off initial cost = cost ÷ \$saved/day = \$1,000 ÷ \$1/day = 1,000 days

(1,000 also acceptable due to days stated in the question)

With the old heater they were spending \$2/day for hot water for showers; with the new heater they would spend \$1/day for hot water for showers. Therefore, the savings is \$1/day, and they would recover the \$1,000 cost of the new hot-water heater in 1,000 days.

Savings calculation alone:

0.2kWh/gallon ÷ 2 = 0.10kWh/gallon saved

0.10kWh/gallon x 2.5 gallons/minute x 10 minutes/person x 4 people x \$0.10/kWh = \$1/day

\$1,000 ÷ \$1/day = 1,000 days

Another way of looking at it:

The new hot-water heater would mean a savings of \$365 per year. \$1,000 ÷ \$365/year = 2.74 years

2.74 years x 365 days/year ≈ 1,000 days (1,000 also acceptable due to days given in problem)

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Question 2 (continued)

(c) Describe TWO practical measures that the family could take that would reduce their overall water use at home. (2 points total—1 point for each measure)

Valid answers to this question include:

Reduce the length of daily showers
Shower less frequently
Install low-flow shower heads and/or toilets
Make sure all water leaks are fixed
Don't let water run while brushing teeth
Run the dishwasher or washing machine only when fully loaded
Use a water-efficient appliance
Hand washing dishes uses less water than running a dishwasher
Use of paper plates and plastic silverware; not using the dishwasher
Use plants outside that require little watering/only water on alternate days/use drip irrigation systems/moisture sensing sprinklers
Sweeping driveway/sidewalks versus washing with water
Don't let water run while washing the car
Wash the car less frequently
Use a car wash
Reuse of water—gray water, bucket in shower to later water plants, rain barrel, etc.

(d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home. (2 points—1 point for each measure)

Valid answers to this question include:

Turn off electric appliances when no one is in the room
Turn off lights in daylight hours
Replace incandescent light bulbs with fluorescents
Increase insulation
Set thermostat to higher temperatures in the summer and lower temperatures in the winter
Use an automatic thermostat that lowers/raises temperatures when no one is in the house
Replace appliances with energy-efficient appliances
Caulk and/or weather-strip exterior doors and windows
Replace single-pane windows with double-pane or other more energy-efficient windows
Open windows/run fans rather than running air-conditioning
Use sweaters/blankets rather than running heater
Reduce usage by not using appliances—hand wash vs. dishwasher
Unplug appliances when not in use.
Line dry clothing instead of using dryer
Lower thermostat of water heater
Add insulation blanket to the hot water heater
Purchase more energy-efficient water heater
Use of passive solar with description

2A

2. The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of \$0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

- (a) Calculate the following. Be sure to show all your work and include units with your answers.
 - (i) The total amount of water that the family uses per year for taking showers
 - (ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater
- (b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs \$1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the \$1,000 initial cost?
- (c) Describe TWO practical measures that the family could take that would reduce their overall water use at home.
- (d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home.

2a. i $4 \text{ people} \times \frac{10 \text{ min/day}}{\text{person}} \times \frac{365 \text{ days}}{\text{year}} \times \frac{5 \text{ gallons H}_2\text{O}}{\text{min}} = 73000 \text{ gal. H}_2\text{O per year}$

ii $\frac{73000 \text{ gal H}_2\text{O}}{\text{year}} \times \frac{.2 \text{ kWh}}{\text{gal}} \times \frac{\$.10}{\text{kWh}} \times \frac{2.5 \text{ gal/min (from hot water heater)}}{5.0 \text{ gal/min (total water)}} = \130 per year

b $\frac{73000 \text{ gal H}_2\text{O}}{\text{year}} \times \frac{.1 \text{ kWh}}{\text{gal}} \times \frac{\$.10}{\text{kWh}} \times \frac{2.5 \text{ gal/min (from hot water heater)}}{5.0 \text{ gal/min (total water)}} = \$365 \text{ per year} = \$1 \text{ per day}$

~~Therefore~~ Since originally the cost of energy was \$2 per day, the cost has now decreased by \$1 per day. Therefore, it would take 1000 days to recover the \$1000 initial cost.

- c. • They could take shorter showers.
- ~~They could turn off the water from the faucet when they're brushing their teeth.~~

- d. • They could turn off unused lights.
- They could turn off the computer when it's not being used.

• They could turn off the sprinklers when it is raining outside.

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- (a) Calculate the following. Be sure to show all your work and include units with your answers.
 - (i) The total amount of water that the family uses per year for taking showers
 - (ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater
- (b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs \$1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the \$1,000 initial cost?
- (c) Describe TWO practical measures that the family could take that would reduce their overall water use at home.
- (d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home.

~~a)(i) $10 \text{ min} \times 5 \text{ gal/min} = 50 \text{ gal}$
 $50 \text{ gal} \times 4 \text{ people} = 200 \text{ gal}$
 Total water used = 200 gal/year~~

~~(ii) $10 \text{ min} \times 2.5 \text{ gal/min} \times 0.2 \text{ kWh/gal} = 5 \text{ kWh}$
 $5 \text{ kWh} \times \$0.10/\text{kWh} = 0.50$~~

a)(i) $10 \text{ min} \times 5 \text{ gal/min} \times 4 \text{ people} = 200 \text{ gal. (per day)}$
 $200 \text{ gal} \times 365 \text{ days} = 73000 \text{ gal/year}$
Annual Total water use = 73000 gal/year

(ii) $10 \text{ min} \times 2.5 \text{ gal/min} \times 0.2 \text{ kWh/gal} = 5 \text{ kWh (per day)}$
 $5 \text{ kWh} \times \$0.10/\text{kWh} \times 365 \text{ days} = \152.5
Annual Total cost = \$152.5

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$$b) 10 \text{ min} \times 2.5 \text{ gal/min} \times 0.1 \text{ kWh/gal} = 2.5 \text{ kWh (per day)}$$

$$2.5 \text{ kWh} \times \$0.10/\text{kWh} = \$0.25 \text{ (per day)}$$

$$\$1000 \div \$0.25/\text{day} = 4000 \text{ days}$$

$$\boxed{\text{Time to recover initial cost} = 4000 \text{ days}}$$

c) To reduce a family's overall water consumption, a practical measure is to water the lawn less and more efficiently. Watering the lawn at night is more efficient than the day because it reduces evaporation. Watering the lawn (depending on the climate) twice ~~a week~~ or three times a week reduces water use greatly. Also, since most household water is consumed by flushing the toilet, a low-flush toilet could be purchased to cut back on this use of water.

d) To reduce a family's energy consumption, better insulation of their home would help. Much of the energy consumed goes to controlling a home's climate, and super insulating the home prevents leaks and requires less energy and heat to maintain a comfortable temperature. The family could also stop using incandescent light bulbs as they are far less efficient than fluorescent lights and require more energy to put out light.

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2C1

2. The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of \$0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

- (a) Calculate the following. Be sure to show all your work and include units with your answers.
 - (i) The total amount of water that the family uses per year for taking showers
 - (ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater
- (b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs \$1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the \$1,000 initial cost?
- (c) Describe TWO practical measures that the family could take that would reduce their overall water use at home.
- (d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home.

(A)(i)	40	10 (5.0 gal/min) × 10 min	0.10 kWh	10 min	0.10
	7	2.0		0.20 kWh	50 min
	280				100.00

10 kWh/gallon per year

(ii)	5.0 gall.	10.0 min	500	20.0
	2.5	2.5 gallon	10000	
	4.0			
	10000	50.00		

(B) It would take half a year for the new hot-water heater to recover the \$1000 initial cost?

(C) Two practical measures that the family could take that would reduce their overall water use at home is to one, reduce the amount of time the take showers and two, take a shower every

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2C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

Other day,

(d) Two conservation measures that the family could take to reduce the total amount of energy that they use at home is take out leisure electronics such as TVs and microwaves and to take more colder showers especially in the summer.

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AP[®] ENVIRONMENTAL SCIENCE 2007 SCORING COMMENTARY

Question 2

Overview

The purpose of this data-based question was to assess the students' ability to analyze information, to calculate water use and electricity costs, and to calculate the cost savings from replacing an old water heater with a more efficient one. It also measured students' ability to recognize home water conservation and energy conservation measures.

Sample: 2A

Score: 10

Part (a): Two points were earned in (a)(i): 1 point for correctly calculating the number of gallons used per year for showering, and 1 point for the correct answer with units. Two points were earned in (a)(ii): 1 point for correctly calculating the annual cost in dollars per year for electricity in the setup, and 1 point for the correct answer with units.

Part (b): Two points were earned: 1 point for correctly calculating the savings per year from the new hot-water heater in the setup, and 1 point for the correct answer.

Part (c): Two points were earned for water conservation measures: 1 point for "shorter showers" (reducing the length), and 1 point for turning "off the sprinklers when it is raining outside."

Part (d): Two points were earned for energy conservation measures: 1 point for turning "off unused lights," and 1 point for turning "off the computer when it's not being used."

Sample: 2B

Score: 6

Part (a): Two points were earned in (a)(i): 1 point for correctly calculating the number of gallons used per year for showering, and 1 point for the correct answer with units. No points were earned in (a)(ii). The student incorrectly calculates the annual cost in dollars per year for electricity in the setup, and no point was earned for an incorrect answer.

Part (b): No points were earned. The student incorrectly calculates the savings per year from the new hot-water heater in the setup by neglecting to account for the four people in the family. No point was earned for an incorrect answer.

Part (c): Two points were earned for water conservation measures: 1 point for watering "the lawn less" and "at night" to reduce evaporation losses, and 1 point for purchasing "a low-flush [flow] toilet."

Part (d): Two points were earned for energy conservation measures: 1 point for better insulation, and 1 point for using more energy-efficient fluorescent lights rather than incandescent lights.

Sample: 2C

Score: 3

Part (a): No points were earned in (a)(i). The student incorrectly calculates the number of gallons used per year for showering, and no point was earned for the incorrect answer. No points were earned in (a)(ii). The student incorrectly calculates the annual cost in dollars per year for electricity in the setup, and no point was earned for an incorrect answer.

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Question 2 (continued)

Part (b): No points were earned. The student does not show a setup, and no point was earned for an incorrect answer.

Part (c): Two points were earned for water conservation measures: 1 point for reducing “the amount of time they take showers,” and 1 point for taking “a shower every other day.”

Part (d): One point was earned for energy conservation measures (for not using electronic appliances). The cooler showers did not earn a point, because the question states that conservation measures must be other than from reducing hot water use. The remainder is an insufficient description involving energy conservation.