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.

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3. In the mid 1970s, Sherwood Rowland and Mario Molina predicted a thinning of the stratospheric ozone layer over Antarctica. The thinning was confirmed in the late twentieth century and has continued into the twenty-first century.

   (a) Identify the class of chemical compounds that is primarily responsible for the thinning of the stratospheric ozone layer and describe TWO major uses for which these chemicals were manufactured.

   (b) Describe how the chemical compounds that you identified in part (a) destroy stratospheric ozone molecules. You may include chemical equations as part of your answer.

   (c) Identify the major environmental consequence of the depletion of stratospheric ozone and describe TWO effects on ecosystems and/or human health that can result.

   (d) Ozone formed at ground level is a harmful pollutant. Describe TWO effects that ground-level ozone can have on ecosystems and/or human health.

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)

(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 then 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