(a) The map shows locations of both successful and unsuccessful turtle nests.

(i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
(ii) **Identify** the dependent variable in the study.
(iii) Based on the information provided, **identify** a likely scientific question for the study.
(iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
(v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.

(b) Mercury can affect organisms and ecosystems in many ways.

(i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
(ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
(iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
(iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.

(c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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**Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.**





GO ON TO THE NEXT PAGE.

3. Increasing global urbanization causes associated problems such as the formation of urban heat islands.

(a) **Describe** how urbanization leads to the formation of urban heat islands.

(b) Urban heat islands have been linked to a variety of environmental problems.

(i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands.

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands.

(c) Urban areas are increasingly using solar energy to generate electricity for residences and businesses.

(i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from $0.11 per kWh to $0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work.

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work.

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August.

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**Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.**

**(ii)** **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions. **1 point**

Accept one of the following:

- Loss of habitat/productivity in spring-fed ecosystems as springs dry up
- Loss of habitat/productivity/degraded water quality in streams and estuaries fed by groundwater discharge
- Soil erosion as vegetation dies as a result of lowered water table and roots no longer hold soil
- Desertification as a result of lowered water table

**(iii)** **Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption. **1 point**

- The ocean water flows into aquifers (saltwater intrusion), contaminating the aquifer with saltwater.

**Total for part (b)** **3 points**

**(c) (i)** **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil. **1 point**

Accept one of the following:

- Increase fuel economy standards for motor vehicles.
- Invest in renewable energy resources.
- Use tax incentives to encourage sales of hybrid/electric vehicles.
- Subsidize projects that increase the use of public transportation/walking/cycling.
- Create tax incentives for companies offering work-from-home options.
- Increase gasoline tax/reduce oil subsidies.

**(ii)** **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change. **1 point**

Accept one of the following:

| Governmental action proposed in (c)(i) | Justification of the action proposed by stating a potential environmental advantage |
|---|---|
| Increase fuel economy standards for motor vehicles | • Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain<br>• Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations |

| | |
|---|---|
| | • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations |
| Invest in renewable energy resources | • Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain<br>• Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations<br>• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations |
| Use tax incentives to encourage sales of hybrid/electric vehicles | • Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain<br>• Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations<br>• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations |
| Subsidize projects that increase the use of public transportation/walking/cycling | • Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain<br>• Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations<br>• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations |
| Create tax incentives for companies offering work-from-home options | • Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain<br>• Decreased oil consumption, which leads to fewer oil spills/decreased groundwater |

## Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

**(a)** **Describe** how urbanization leads to the formation of urban heat islands. **1 point**

Accept one of the following:

- Urban buildings can block wind currents, increasing local temperatures.
- Urban building materials/structures such as roads, sidewalks, and/or buildings hold in heat, causing the temperatures to increase.
- Urban areas have fewer trees, resulting in less shade/less transpiration, causing temperatures to increase.
- Urban areas have large numbers of vehicles/air conditioners/machinery that produce waste heat, causing temperatures to increase.

**Total for part (a)** **1 point**

**(b)** **(i)** **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands. **1 point**

Accept one of the following:

- Plant green roofs on buildings/plant vegetation around buildings/increase green space.
- Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces.
- Increase efficiency of a system that produces waste heat (vehicles, air conditioners).
- Decrease use of a system that produces waste heat (vehicles, air conditioners).

**(ii)** **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands. **1 point**

Accept one of the following:

| Solution proposed in (b)(i) | Justification solution with additional benefit |
|---|---|
| Plant green roofs on buildings/plant vegetation around buildings/increase green space | • Provides food crops<br>• Creates habitat for biodiversity<br>• Slows/captures runoff<br>• Insulates buildings, which reduces heating/cooling costs<br>• Provides aesthetic/cultural/recreational benefits<br>• Reduces air pollution (particulates, $O_3$, $SO_2$, $NO_2$, CO)<br>• Filters the air<br>• Removes carbon from the atmosphere |

| | |
|---|---|
| Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces | • Reflects solar energy, which reduces cooling costs<br>• Reduces energy consumption, which reduces cooling costs |
| Increase efficiency of a system that produces waste heat (vehicles, air conditioners) | • Decreased production of $CO_2$, which reduces climate change<br>• Reduces energy consumption, which reduces costs |
| Decrease use of a system that produces waste heat (vehicles, air conditioners) | • Decreased production of $CO_2$, which reduces climate change<br>• Decreased use of vehicles, which reduces air pollution<br>• Reduces energy consumption, which reduces costs |

**Total for part (b)** **2 points**

**(c) (i)** As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work. **1 point**

One point for the correct setup (must include multiplication by 100 ) to calculate the percent change:

- $\frac{44.5\% - 15.9\%}{15.9\%} \times 100$
- $\left(\frac{44.5\%}{15.9\%} - 1\right) \times 100$

One point for the correct calculation of the percent change: **1 point**

Accept one of the following:

- 179.9%
- 180%

**(ii)** The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from $0.11 per kWh to $0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the change of electricity cost for one year:

- $12{,}900 \text{ kWh} \times \left(\frac{\$0.13 - \$0.11}{\text{kWh}}\right)$
- $12{,}900 \text{ kWh} \times \frac{\$0.13}{\text{kWh}} = \$1677$ **AND** $12{,}900 \text{ kWh} \times \frac{\$0.11}{\text{kWh}} = \$1419;\ \$1677 - \$1419$

One point for the correct calculation of the change of electricity cost for one year: **1 point**

- $258

**(iii)** The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of kWh that can be produced at maximum output:

- $30 \text{ panels} \times \frac{300 \text{ watts}}{\text{panel}} \times \frac{1 \text{ kW}}{1{,}000 \text{ watts}} \times \frac{4 \text{ hours}}{\text{day}} \times \frac{365 \text{ days}}{1 \text{ year}}$

One point for the correct calculation of the amount of kWh that can be produced at maximum output: **1 point**

- 13,140 kWh per year

**Total for part (c)** **6 points**

**(d)** **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August. **1 point**

- During June through August, the Northern Hemisphere is tilted toward the Sun and receives more direct solar energy (per unit area) than the Southern Hemisphere.
- During June through August, the Northern Hemisphere is tilted toward the Sun and has more hours of sunlight.

**Total for part (d)** **1 point**

**Total for question 3** **10 points**