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 • Creates habitat for biodiversity • Slows/captures runoff • Insulates buildings, which reduces heating/cooling costs • Provides aesthetic/cultural/recreational benefits • Reduces air pollution (particulates, O_3, SO_2, NO_2, CO) • Filters the air • Removes carbon from the atmosphere

Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces	• Reflects solar energy, which reduces cooling costs • 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 • 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 • Decreased use of vehicles, which reduces air pollution • 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**