3. Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

   (a) **Identify** a fuel used in a nuclear power plant.

   (b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.

   (c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.

   Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

   (d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

   Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

   (e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.

   (f) 7.4×10^{7} cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.

   (g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

   _____

   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.

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

(a)	**Identify** a fuel used in a nuclear power plant.	**1 point**

Accept one of the following:

- Uranium
- U-235
- Plutonium

(b)	**Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.	**1 point**

Accept one of the following:

- Thermal pollution raises water temperature outside range of tolerance of organisms.
- Thermal pollution decreases dissolved oxygen.
- Water temperature increases, which decreases dissolved oxygen.
- Organisms can be wounded or killed at water intake.
- Water loss through evaporation can decrease stream flow/volume of water.

(c)	In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.	**1 point**

One point for the correct setup to calculate the amount of electricity generated by nuclear power in 2021:

Accept one of the following:

- $(4.1 \times 10^{12} \text{ kWh}) \times 18.9\%$
- $(4.1 \times 10^{12}) \times 0.189$
- $\dfrac{4.1 \times 10^{12}}{100} = \dfrac{x}{18.9}$

One point for the correct calculation of the total amount of electricity generated by nuclear power in 2021:	**1 point**

Accept one of the following:

- 774,900,000,000
- 7.749×10^{11}
- 7.75×10^{11}
- 7.7×10^{11}

Total for part (c)　2 points

(g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

1 point

One point for the correct setup to calculate how much less carbon dioxide would have been produced in 2021:

Accept one of the following:

- $\dfrac{(1.0 \text{ kg} - 0.42 \text{ kg})}{1 \text{ kWh}} \times \left(8.99 \times 10^{11} \text{ kWh}\right)$

- $(1.0 \text{ kg} - 0.42 \text{ kg}) \times \left(8.99 \times 10^{11} \text{ kWh}\right)$

- $(1.0 - 0.42) \times \left(8.99 \times 10^{11}\right)$

- $\left(\dfrac{8.99 \times 10^{11} \text{ kWh}}{1} \times \dfrac{1 \text{ kg}}{\text{kWh}}\right) - \left(\dfrac{8.99 \times 10^{11} \text{ kWh}}{1} \times \dfrac{0.42 \text{ kg CO}_2}{\text{kWh}}\right)$, THEN
  $8.99 \times 10^{11} \text{ kg CO}_2 - 3.776 \times 10^{11} \text{ kg CO}_2$

One point for the correct calculation of how much less carbon dioxide would have been produced in 2021:

1 point

Accept one of the following:

- 521 billion kg
- 521,420,000,000 kg
- 5.2142×10^{11} kg
- 5.21×10^{11} kg
- 5.2×10^{11} kg

Total for part (g)	**2 points**
Total for question 3	**10 points**