3.2 Grading the Greenhouse Effect Simulation Worksheet

*This tool has "grading" in the title because at this point, students can be held accountable for correct answers. Level 4 (correct) responses to the questions are in **blue bold italics** below. There are also comments about common Level 2 and Level 3 responses to help you with grading and making decisions about what to emphasize in future lessons.*
Red italics suggest ways to grade student responses by giving them points for correct or partially correct answers. There are 23 points total on this worksheet.

Directions: Open the PhET simulation. On the center of the right-side panel under "Atmosphere during…", select "Adjustable Concentration".

1. **Trial 1 –** In the "Greenhouse Gas Concentration" panel, move the slider to "None". Watch the red infrared photons as they move from the surface of the earth to outer space. What observations can you make about their movement?

They are only moving up into space, they are not staying in the atmosphere. They are in low concentration.
1 point for correct response.

2. **Trial 2 –** Next, move the slider to "Lots". Again, watch the red infrared photons as they move from the surface of the earth to outer space. How has this changed the movement of the infrared photons as they leave the surface of the earth? (You can switch back and forth between the two scenarios if that makes it easier to observe the differences).

They are bouncing around in the atmosphere at a high concentration.
1 point for correct response.

3. Summarize the changes that occurred to the movement of infrared photons as the concentration of greenhouse gases increased:

As greenhouse gas concentrations increased, the movement of infrared photons will…
increase.
1 point for correct response.

4. Why would the movement of infrared photons change in this way if the concentrations of greenhouse gases are increased? (Hint: what makes something a greenhouse gas?).

They would increase because greenhouse gases create a layer around the earth, so the infrared photons cannot escape the atmosphere.
1 point for correct response

5. What is happening to the movement of the yellow light photons as greenhouse gas concentrations are increased?
    a. Fewer light photons can get through the atmosphere.
    b. More light photons can get through the atmosphere.
    c. No changes occurred to the movement of light photons.
    1 point for correct response

6. How do your observations in the previous question relate to the Greenhouse Effect? Return to the definition in the reading if needed.

Greenhouse gases allow light photons to pass through them.
1 point for correct response.

7. What would happen to the movement of infrared photons if we increased the concentration of N_2 or O_2? Choose one of the options below and explain your choice:
    a. More infrared photons would leave the atmosphere more quickly.
    b. Fewer infrared photons would be able to leave the atmosphere as quickly.
    c. No change would occur to the movement of infrared photons.
    1 point for correct response.

because ***those gases do not change the way energy moves from the Earth's surface to space.***
1 point for correct response.

8. In the "Atmosphere during…" panel, select each time period option (Today, 1750, Ice Age) and complete the table below using the information in the "Greenhouse Gas Composition" panel:

	CO_2 (ppm)	**Temperature**
Today	***388***	***59***
1750	***280***	***53***
Ice Age	***180***	***33***

6 points for correct response (1 point per cell).

9. What do you notice in regards to the relationship between the concentration of CO_2 and the temperature?

As CO_2 increases, temperature increases.
1 point for correct response.

10. Next, click on the "Photon Absorption" tab from the blue tabs in the upper left of the screen. Under the "Atmospheric Gases" panel, select CO_2. On the "radiation gun" on the left-hand side of the screen, make sure that the "Infrared Photon" option is selected. Move the slider on the gun all the way to the right and observe how the infrared photons respond when they encounter the CO_2 molecule. Then circle one of the options below:

When an infrared photon hits CO_2, the photon's movement is… **Unchanged** ***Scattered***
1 point for correct response.

11. Now select the "Visible Photon" option on the gun. Make sure the slider is still adjusted so that it is all the way to the right. Observe how the visible light photons respond when they encounter the CO_2 molecule. Then complete the sentence below:

When a visible light photon hits CO_2, the photon's movement is… ***Unchanged*** **Scattered**
1 point for correct response.

12. How do your observations in this exercise relate to the Greenhouse Effect? Revisit the definition in the reading if needed.

The light photons pass through CO_2, which allows sunlight to reach the Earth. It scatters infrared photons, which causes them to bounce around in the atmosphere.
1 point for correct response.

13. Next, select N_2 under the "Atmospheric Gases" panel. Select the "Infrared Photon" option on the gun. Move the slider on the gun all the way to the right. Then complete the sentence below:

When an infrared photon hits N_2, the photon's movement is… ***Unchanged*** **Scattered**
1 point for correct response.

14. Now select the "Visible Photon" option on the gun. Make sure the slider is still adjusted so that it is all the way to the right. Observe how the visible light photons respond when they encounter the N_2 molecule. Then complete the sentence below:

When a visible light photon hits N_2, the photon's movement is… ***Unchanged*** **Scattered**
1 point for correct response.

15. How did the interactions of CO_2 and infrared photons differ from the interactions of N_2 and infrared photons?

CO_2 scatters infrared photons and does not change visible photons. N_2 does not change visible or infrared photons.
1 point for correct response.

16. How can the different molecular properties of CO_2 and of N_2 help to explain these differences?

N_2 is made up of 2 of the same molecules, which causes them to vibrate the same way, which allows infrared and visible photons pass through them. CO_2 is made up of 2 different molecules, which have different vibrational patterns. This causes them to scatter infrared photons as they pass through.
1 point for correct response.

17. How do these molecular properties determine whether or not an atmospheric molecule can be a greenhouse gas?

Molecules with 2 or more elements have different vibrational patterns. They allow light to pass through them but slow the loss of leaving radiation.
1 point for correct response.