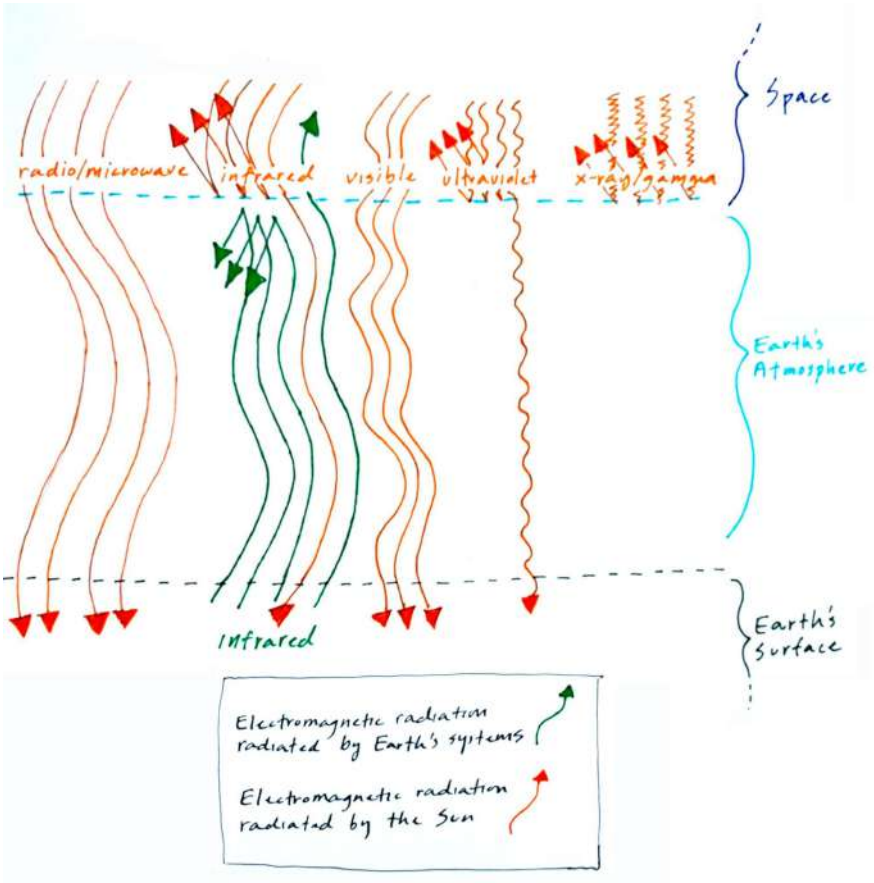
Name: _____ Date: _____

Explaining Temperature Rise Transfer Task

Question 1

Almost all of the energy entering Earth's systems comes from the Sun. That energy travels through empty space in the form of *electromagnetic radiation*. Look at the model of Earth's atmosphere below. Much like the door of a microwave oven, the atmosphere allows almost all of the visible light from the Sun to transmit into Earth's systems, but reflects or absorbs some radiation with longer and shorter wavelengths, preventing it from reaching Earth's surface. The electromagnetic radiation that is transmitted through the atmosphere will mostly be absorbed by air, plants, rock, and water. Earth's systems together absorb about 71% of incoming solar radiation.

Model of Matter-Energy Interactions in Earth's Atmosphere



1a. Use the *Model of Matter-Energy Interactions in Earth's Atmosphere* above to fill in the first column of the table below, using check marks or X's, to show which types of electromagnetic radiation are radiated by the Sun toward Earth.

1b. Use the *Model of Matter-Energy Interactions in Earth's Atmosphere* to fill in the second column of the table below, to show which types of incoming electromagnetic radiation are mostly reflected back into space or absorbed by matter in Earth's atmosphere.

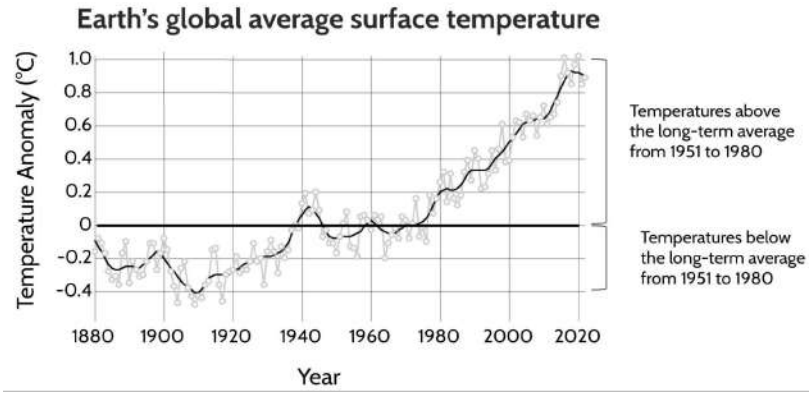
1c. Use the *Model of Matter-Energy Interactions in Earth's Atmosphere* to fill in the third column of the table below, to show which types of incoming electromagnetic radiation are mostly transmitted to the surface by matter in Earth's atmosphere.

1d. After absorbing different types of electromagnetic radiation from the Sun, Earth's systems also radiate electromagnetic radiation. But unlike the Sun, which is very hot, Earth's systems radiate only certain wavelengths of electromagnetic radiation. Use the *Model of Matter-Energy Interactions in Earth's Atmosphere* to fill in the last column of the table below, to show which types of electromagnetic radiation are radiated back out by Earth's systems.

Energy input to Earth's systems	**a. Radiated by the Sun toward Earth**	**b. Mostly reflected or absorbed by matter in Earth's atmosphere**	**c. Mostly transmitted by matter in Earth's atmosphere**	**d. Radiated by Earth's systems**
Radio waves/microwave radiation				
Infrared radiation				
Visible light				
Ultraviolet radiation				
X-rays/gamma rays				

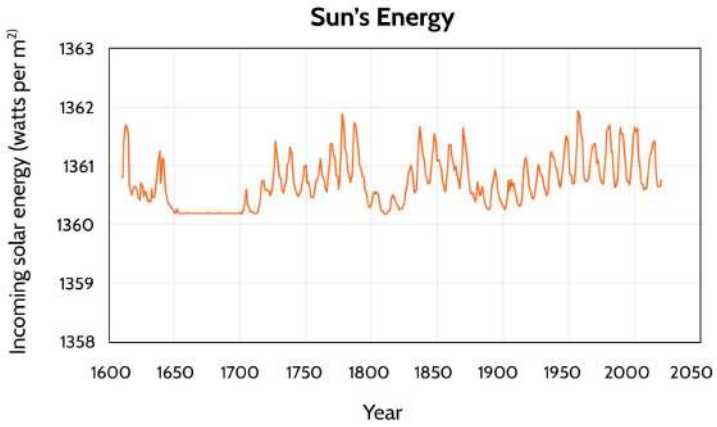
Question 2

The amount of energy in a system is determined by the *energy inputs* (how much energy is transferred into the system) minus the *energy outputs* (how much energy is transferred out of the system). The graph below shows changes in temperatures near Earth's surface over the past 150 years. The rise in temperature indicates an imbalance in the system's energy inputs and outputs.



Data Source: NASA/GISS

Although there have been natural variations in the Sun's energy over the past few hundred years, data show that there has **not** been a significant increase in energy inputs to Earth's systems, as shown in the graph below.



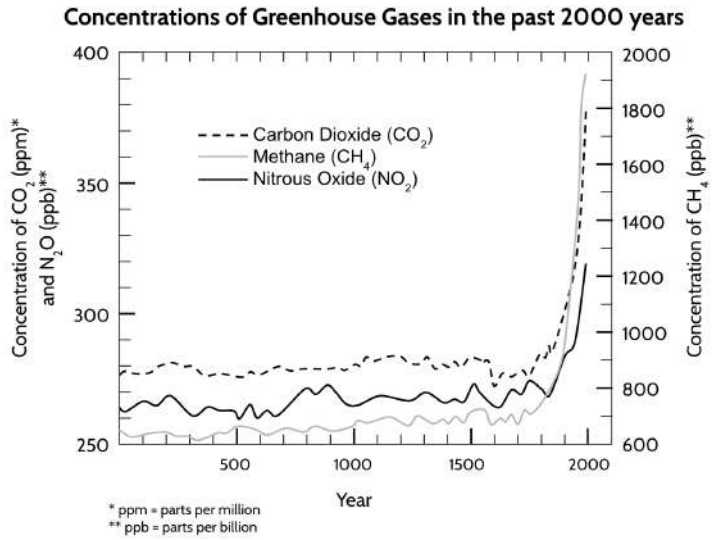
Adapted from NOAA Climate.gov, (2016)

2a. Do the data in the graphs above indicate that electromagnetic radiation leaving Earth's systems (output) has been increasing, decreasing, or staying the same? Over what time scale, and how do you know?

2b. What matter-energy interactions in Earth's atmosphere could explain what is happening to the electromagnetic radiation that should be transmitted back out into space? How do you know?

Question 3

Greenhouse gases are compounds that absorb infrared radiation, preventing it from leaving Earth's atmosphere. Concentrations of greenhouse gases in our atmosphere have been increasing drastically over the past few hundred years due to human industry, as shown in the graph below.



Data Source: Forster et al. (2007)

The data table to the right provides *residence data* for greenhouse gases in our atmosphere. Residence data show how long the gases that are released into the atmosphere will stay there before they transition into a different Earth system, such as the *biosphere* (life), *geosphere* (crust), or *hydrosphere* (oceans and other water).

Greenhouse Residence	
Greenhouse Gas	**Lifetime in Earth's Atmosphere**
Carbon Dioxide	300-1000 years
Methane	12 years
Nitrous Oxide	114 years
Water	4-10 days

3a. Scientists are concerned about the impact of greenhouse gases on global temperatures. They argue that if we fail to reduce the emission of these gases by 2030, it will become increasingly challenging for future generations to reduce the gases' effects on global temperature. Based on the data in the graph and the table above, explain which greenhouse gas will have the greatest effect on future generations, and why.

3b. Using the *Model of Matter-Energy Interactions in Earth's Atmosphere*, develop an explanation for how interactions between electromagnetic radiation and greenhouse gases could cause an increase in Earth's temperature.

- Be sure to explain what is causing these interactions to shift over the past few hundred years, and how evidence (from the data included in this assessment or from our experiments with the microwave oven) supports your explanation.
- Use any combination of words, diagrams, and symbols in your explanation.

References

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D. W., ... & Whorf, T. (2007). Changes in atmospheric constituents and in radiative forcing. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change*.

Coddington, O., Lean, J. L., Pilewskie, P., Snow, M., and Lindholm, D. (2016). A Solar Irradiance Climate Data Record, *Bull. Amer. Meteorol. Soc, 97,* 1265–1282.

Vital signs: Global Temperature. (2022). Retrieved February 10, 2023, from https://climate.nasa.gov/vital-signs/global-temperature/