Objects give off different amounts of light depending upon their temperature. Figure 1, below, shows the energy output of our Sun along with the percent of energy given off by the Sun in the ultraviolet (UV), visible (VIS), and infrared (IR) portions of the electromagnetic spectrum.

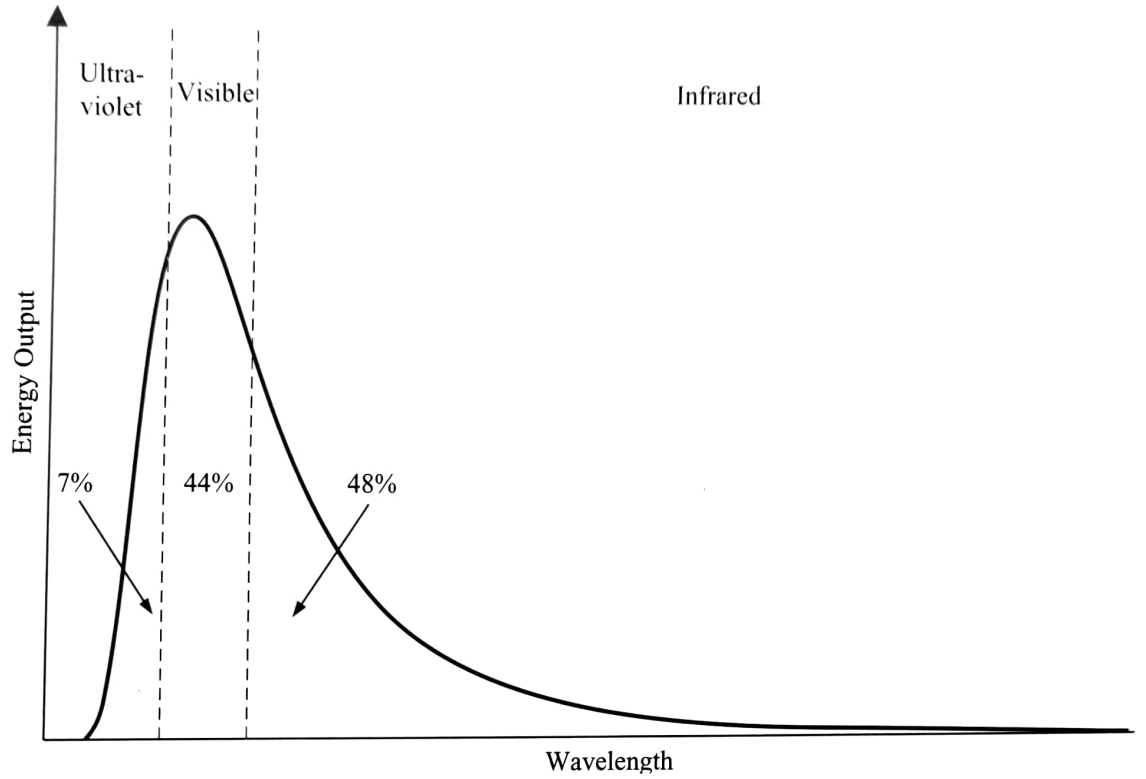

Figure 1

1) Which **TWO** forms of light account for the majority of energy coming from the Sun: ultraviolet, visible, or infrared? Which of the three accounts for the least energy? Provide numbers to support your answer.

2) Consider the following debate between two students regarding the energy given off by the Sun.

Student 1: *I think that the Sun gives off most of its energy at ultraviolet wavelengths because ultraviolet light is more intense than visible light and you always hear about ultraviolet light causing sunburns.*

Student 2: *Even though UV photons are more energetic than visible photons, the Sun simply gives off fewer ultraviolet photons and gives off way more visible and infrared photons. So I think that these longer wavelength photons account for most of the energy coming from the Sun.*

Do you agree or disagree with either or both of these students? Explain your reasoning.

Earth's surface temperature is affected by light that is absorbed at the surface. However, a photon's ability to travel through our atmosphere depends upon its wavelength. Figure 2 below shows that some wavelengths of light are absorbed in our atmosphere more than others. The figure also lists the primary gas molecules responsible for absorbing the different wavelengths of light.

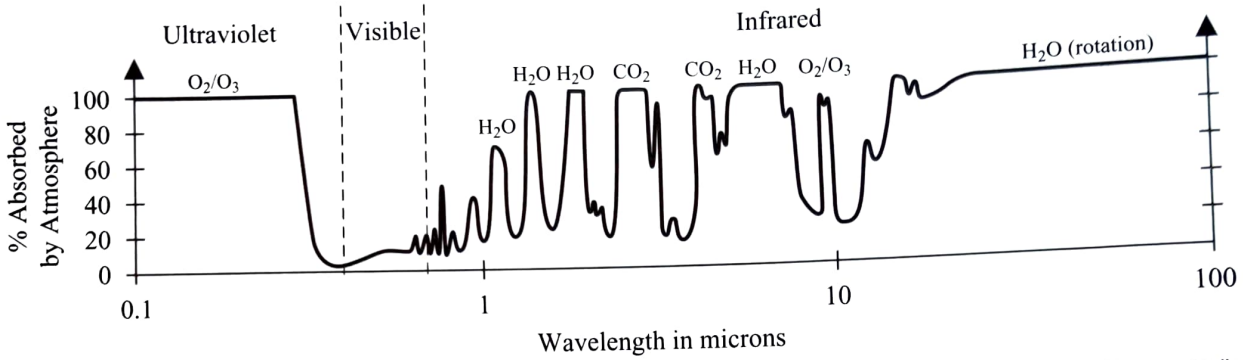

Figure 2

3) Comparing the visible and the infrared types of light, which would you say has an easier time getting through our atmosphere? Which experiences more absorption?

4) Comparing the ultraviolet and the infrared types of light, which would you say has an easier time getting through our atmosphere? Which experiences more absorption?

5) Based upon Figures 1 and 2, why is ultraviolet light **NOT** an important energy source for heating the surface of Earth?

6) What gas molecules are primarily responsible for the absorption of each of the following types of light in our atmosphere?

Type of Light	Molecule(s) Responsible for Absorption
Ultraviolet	
Visible	
Infrared	

Molecules that are transparent to visible light but absorb and re-emit infrared light are known as "*greenhouse gases.*"

7) What are the two greenhouse gases most responsible for absorbing infrared light in Earth's atmosphere?

Once visible light from the Sun reaches the surface of Earth, some of the light is reflected back toward space as visible light, and the remaining light is absorbed by the ground. Reflected light does not change the temperature of the surface, whereas absorbed light causes the temperature of the surface to increase. Earth's heated surface then gives off infrared light to Earth's atmosphere. As an example, on a hot day, black asphalt absorbs more visible light and gives off more infrared light than does a white crosswalk.

8) The Sun is approximately 6000 K at the surface and has an energy distribution that peaks at visible wavelengths; Earth's surface is much cooler at about 288 K. What type of light do you think Earth's surface primarily gives off: ultraviolet, visible, or infrared light? Explain your reasoning.

9) Does Earth's surface give off light at night? If so, what type? If not, why not?

10) Consider the following debate between two students regarding the energy given off by Earth's surface.

Student #1: *The Sun mainly gives off visible light and so does Earth's surface because I can see it during the daytime.*

Student #2: *But that's just reflected sunlight. Earth's surface is much cooler than the Sun and mostly gives off energy closer to the kind that our bodies give off — infrared light. I'm not sure, but I think the surface probably radiates infrared light during both the daytime and the nighttime based upon its temperature.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

11) Will the light given off by Earth's surface easily travel back through the atmosphere to space or will it be absorbed by molecules in the atmosphere? Explain your reasoning.

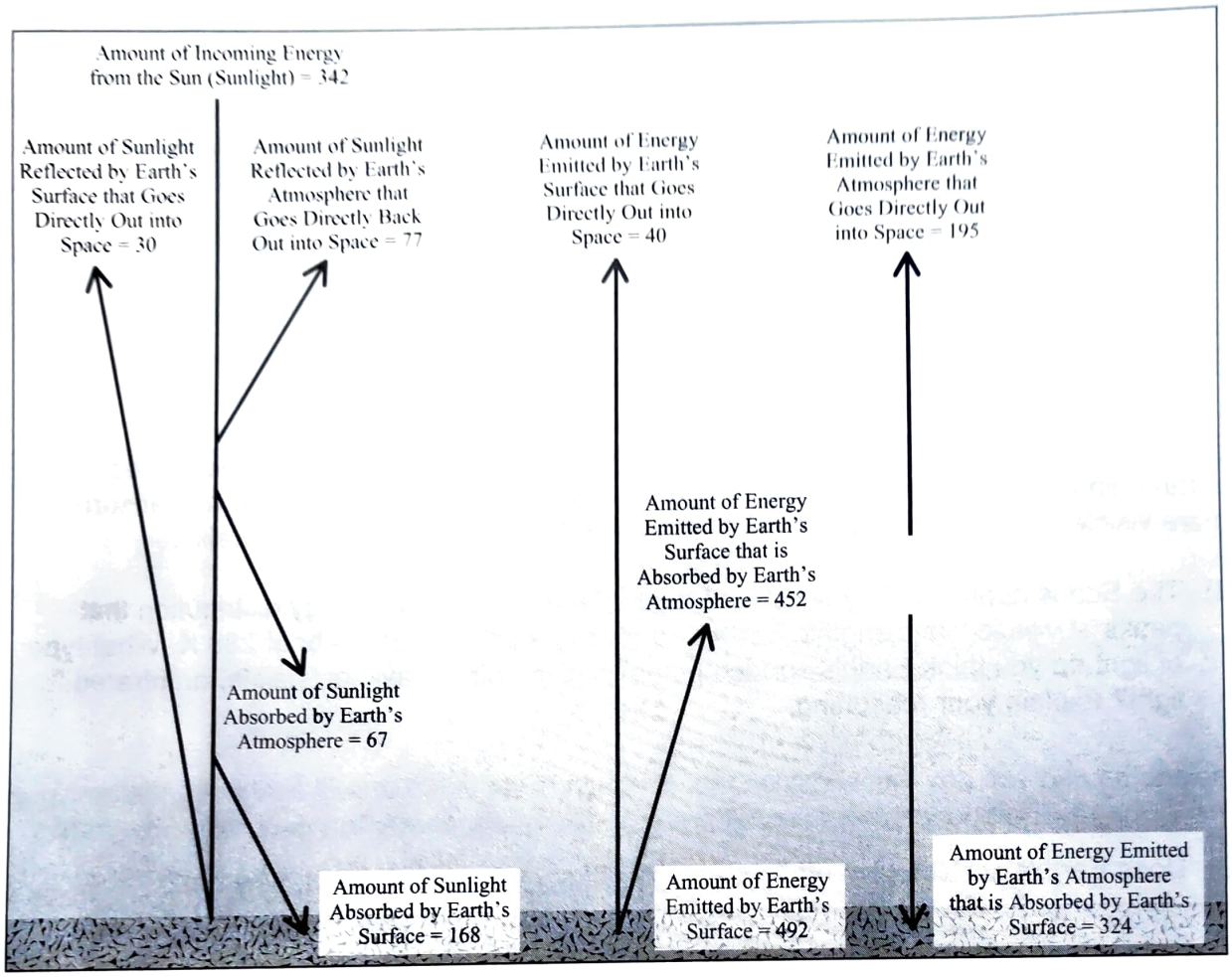

Figure 3

Figure 3 shows how light/energy flows through the Earth system for the "greenhouse effect." The numbers listed describe the amount of energy flowing through the system (units of watts per square meter). A larger number indicates that more energy is flowing through that labeled pathway.

12) How does the total amount of energy coming from the Sun compare to the total amount of energy leaving Earth to space? Provide numbers to support your answer.

13) What type of light primarily heats Earth's surface and where does this light come from? What type of light primarily heats Earth's atmosphere and where does this light come from?

14) Is more energy absorbed by Earth's surface in the form of light coming from the Sun or from light emitted by Earth's atmosphere? Explain your reasoning, and provide numbers to justify your answer.

15) Due to the light absorbed by Earth's surface that was emitted by Earth's atmosphere, is Earth's temperature near the surface going to be warmer or cooler than it would be without this absorbed light?

16) Fill in the empty boxes in Figure 4 below with the correct type(s) of light. Use the abbreviations UV, IR, and VIS.

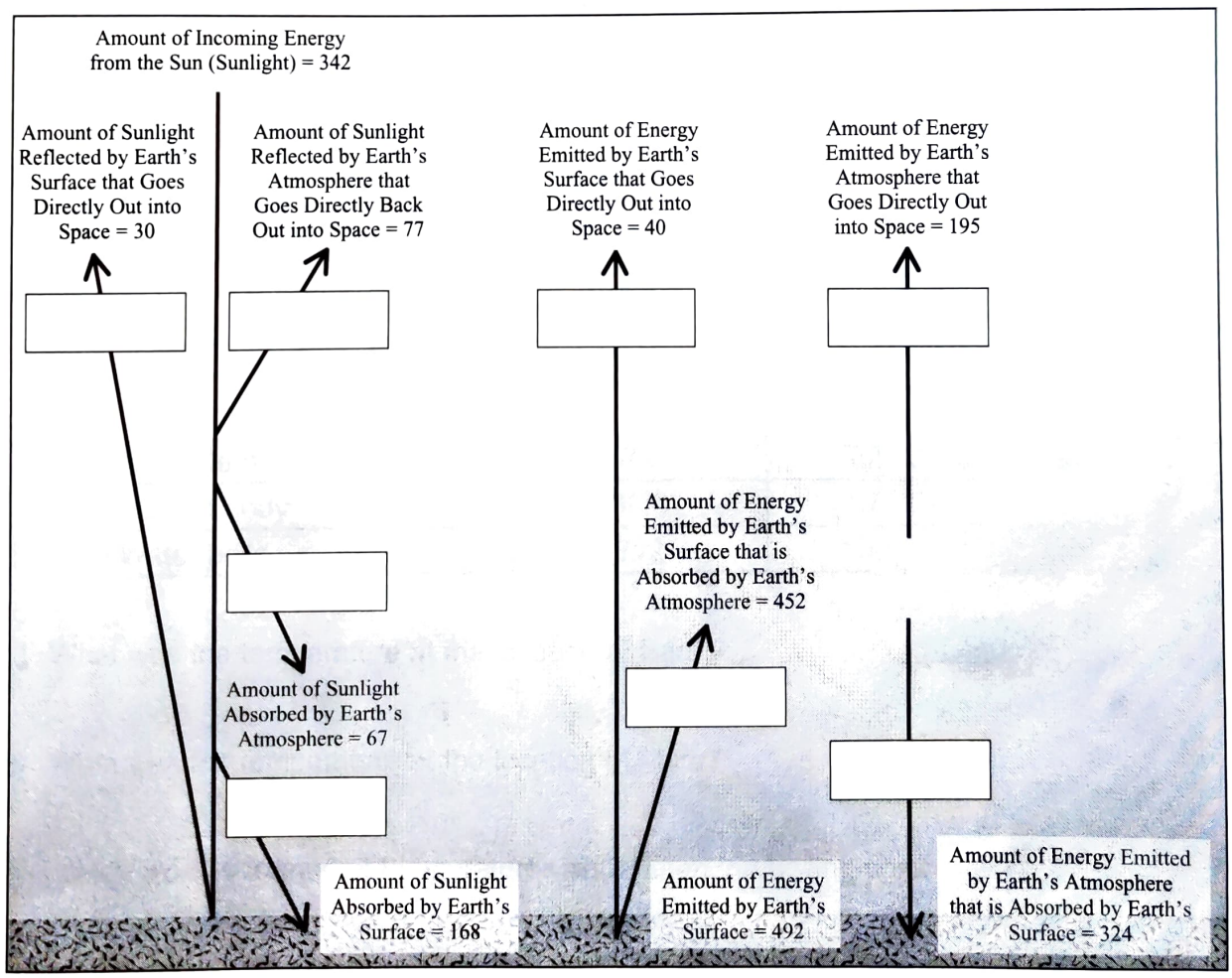

Figure 4

The flow of energy shown in Figures 3 and 4 is the source of the natural "atmospheric greenhouse effect." Visible light penetrates the atmosphere and is absorbed by the surface. The heated surface gives off infrared light that is then absorbed by the atmosphere. The heated atmosphere gives off infrared light out to space and also back down to Earth's surface, making the surface temperature warmer than it would be without a greenhouse effect. The amount of energy entering and leaving the Earth system can be balanced, but Earth's surface temperature is warmer because the surface is heated both by visible light from the Sun and infrared light sent back from the atmosphere.

17) Consider the following debate between two students regarding the greenhouse effect.

Student 1: *So the greenhouse effect is caused by infrared light being trapped in Earth's atmosphere. Visible light from the Sun heats the ground, but the infrared light given off by the ground gets permanently trapped in the atmosphere and can never escape.*

Student 2: *I think that's close. But based on Figure 3, all of the arrows balance and just as much energy leaves Earth as comes in. I think the greenhouse effect makes the surface hotter than it would be without greenhouse gases because the ground gets visible light from the Sun* **AND** *infrared light given off by the atmosphere that is sent back to the surface.*

Do you agree or disagree with either or both of the students? Explain your reasoning.