Period 14 Activity Solutions: Energy in Nature

14.1 The Earth-Sun System

1) Energy from the sun

Observe the models of the Earth, Moon, and Sun in the room.

a) Imagine that the distance between the Earth and the Sun is represented by the length of a football field (100 yards or 91 meters). The Sun, at one goal line, is represented by a ball 85 cm in diameter (the size of a large beach ball or exercise ball).

What would be the diameter of a model of the Earth at the opposite goal line?

8 mm (about the size of an M & M candy)

What would be the diameter of a model of the Moon? **_2 mm_**

How far would the model of the Moon be from the model of the Earth? **_23 cm_**

b) It takes radiation from the Sun about 8.3 minutes to reach the Earth. How far away is the Earth from the Sun?

$$S = \frac{D}{t} \text{ or } D = S\,t = (3 \times 10^{8}\ m/s) \times (8.3\ min \times 60\ s/min) = 1.55 \times 10^{11}\ m$$

2) How much energy does the Earth receive from the Sun?

a) How many watts of energy does the Sun produce? **_3.90×10^{26} watts_**

b) Only about 1.76×10^{17} watts of the Sun's energy actually reaches the Earth. What percent is this of the total energy produced by the Sun?

$$\frac{1.76 \times 10^{17}\ watts}{3.90 \times 10^{26}\ watts} = 4.5 \times 10^{-10} = 4.5 \times 10^{-8}\ \% = 0.000000045\ \%$$

c) Where does the rest of the Sun's energy go?

The energy radiates out into space uniformly all directions. Only a tiny fraction of the Sun's energy is intercepted by the Earth.

d) What is the source of the Sun's energy?

nuclear fusion reactions in which hydrogen is converted into helium

3) What form of energy is received from the Sun?

a) What form of energy does the sun give off?

The sun gives off electromagnetic radiation with a frequency (or wavelength) centered on that of visible light.

b) Your instructor will demonstrate a light bulb filament at different temperatures. Look at the filament through a diffraction grating. Describe any changes you see in the spectrum as the filament glows hotter.

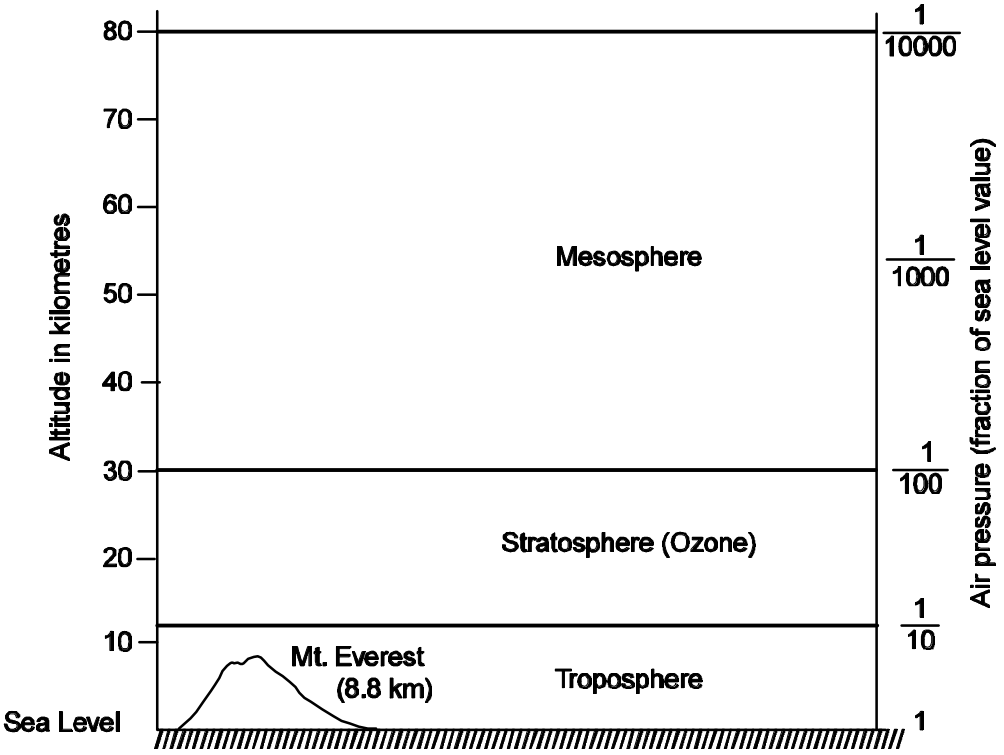
The red end of the spectrum is more prominent when the light is not as bright (the filament is less hot). The blue end of the spectrum becomes more prominent as the light becomes hotter (by adjusting the light to be brighter).

c) How does the temperature of an object relate to the frequency of the energy it gives off (its electromagnet spectrum)?

The hotter an object is, the higher the average frequency and the shorter the average wavelength of radiation given off by it.

14.2 The Earth's Atmosphere

4) Atmospheric Layers



a) On the diagram above, fill in the names of the layers of the Earth's atmosphere and the approximate percent of the Earth's air that is contained in each region. (Hint: note what fraction of the total pressure of the air is measured for each air layer.)

The troposphere extends from sea level to about 12.5 kilometers. The stratosphere extends from 12.5 km to 30 km above sea level. The mesosphere extends from 30 km to 80 km.

From right side vertical axis of the diagram, the air pressure at the top of the troposphere (1/10) is 10 times greater that the air pressure at the top of the stratosphere (1/100) and is 100 times greater than the

air pressure of the mesosphere (1/1,000). Therefore, the troposphere must contain about 90% of the Earth's air, the stratosphere contains about 9%, and the mesosphere contains the remaining 1%.

b) In which atmospheric layer(s) can life exist? **_the troposphere_**

c) In which atmospheric layer is the Earth's ozone layer? **__the stratosphere__**

d) Make a prediction as to how thick the atmosphere would be if the Earth were as large as the globe on your table.

Answer:_0.5 mm, or about the thickness of the plastic ruler_

e) What is the chemical composition of the atmosphere?

The atmosphere is about 78% nitrogen and 21% oxygen. The remaining 1% is made up of argon, carbon dioxide, water vapor, and other gasses.

f) Group Discussion Question: The percent of carbon dioxide in the atmosphere is very small (0.033%). Why does this small concentration make increasing the atmosphere's carbon dioxide concentrations potentially dangerous?

Since the amount of carbon dioxide is so small, its concentration can be more easily influenced by producing additional carbon dioxide. The added carbon dioxide could have a significant effect on the temperature of the Earth.

14.3 The Energy Balance of the Earth

5) Earth's energy balance

a) From the energy balance diagram, what percent of the incoming solar radiation is reflected back into space?

30 % of the incoming radiation is reflected back into space off of clouds, air molecules, and the Earth's surface.

b) Of the solar radiation remaining, what percent is absorbed by the Earth's surface? **_51%_**

c) What happens to the rest of the solar radiation that enters the Earth's atmosphere?

The remaining 19% is absorbed by clouds and air.

d) What form of energy is absorbed by the Earth's surface?

primarily, visible electromagnetic radiation

e) What form of energy is emitted by the Earth's surface?

primarily, infrared electromagnetic radiation

f) What can block the radiation from the Earth from escaping into space?

Gases that absorb infrared radiation, such as water vapor and carbon dioxide, absorb infrared radiation. These gases are known as greenhouse gases because their presence in the atmosphere can cause adjustments to the temperature of the Earth.

g) What percent of the solar radiation entering the Earth's atmosphere is radiated back into space? **100%**

h) Group Discussion Question: What are the consequences for the Earth if not all of the incoming radiation is radiated back into space?

6) Sunlight incident on the Earth

Your instructor will explain how to use a globe and a flashlight to model the sunlight incident on different regions of the Earth.

a) Point a flashlight light horizontally at the equator of the globe. Stand the peg board between the light and the globe about 5 cm from the globe's equator and 20 cm from the flashlight. Hold the small brown square flat along the equator.

How many dots of light on the globe fit inside the brown square? **_4_**

b) Keeping the pegboard the same distances from the flashlight and the globe, raise the flashlight to point it horizontally at the high northern latitudes (for example, at Alaska). Hold the brown square flat along this area.

Now how many dots of light on the globe fit inside the brown square? **_ 1 or 2_**

c) How does the amount of sunlight striking the Earth at higher latitudes compare the to sunlight striking the Equator?

At higher latitudes the same amount of sunlight falls over a much greater area than at lower latitudes.

d) What effect does your findings in part c) have on the weather?

Since the higher latitudes receive less sunlight (solar insolation), the temperatures are not as warm.

e) Group Discussion Question: What is another reason that the higher latitudes receive less sunlight?

At higher latitudes, sunlight incident on the Earth must pass through a thicker layer of atmosphere. This additional atmosphere absorbs and blocks some additional sunlight.

7) The Earth's seasons

Your instructor will discuss the causes of the Earth's seasons.

a) Place the light bulb in the center of your table so that it shines on the equator of the globe. Move the globe around the light bulb to simulate the Earth's seasons. (Hint: the direction that the axis of the globe tilts is important.)

b) What causes the Earth's seasons? Is the distance of the Earth from the Sun a factor?

Seasons are caused by the tilt of the Earth's axis. The distance from the Earth to the Sun cannot be a significant factor, since the Earth is closest to the Sun in December.