TOPIC 5

Energy in Earth Processes

Vocabulary

condensation
conduction
convection
crystallization
electromagnetic energy
electromagnetic spectrum
energy
heat energy
joules
mechanical energy
nuclear decay
radiation
solidification
specific heat
temperature
texture
vaporization
wavelength

Topic Overview

Energy, like mass, time, or distance, is one of the basic attributes of the universe. **Energy** is the ability to do work. Everything you do—in fact, everything that is done in the universe—involves the use or transfer of energy. Earth can be described as a huge machine driven by two major heat engines—one external and one internal. Earth's external engine—the one that drives most Earth surface processes—is powered mainly by energy from the sun. Heat from the interior of Earth and the resulting mechanical energy powers Earth's internal heat engine.

Electromagnetic Energy

Visible light is the type of electromagnetic energy you are probably most familiar with. Visible light waves are the parts of the electromagnetic energy that is radiated by the sun and observed with the human eye. **Electromagnetic energy** is a type of energy that is radiated, or given off, in the form of transverse waves from all matter not at absolute zero. Absolute zero, that is, 0 Kelvin or −273° Celsius, is theoretically the lowest possible temperature and the one at which particles of matter have no motion. Transverse waves vibrate at right angles to the direction in which they are moving. (See Figure 5-1.)

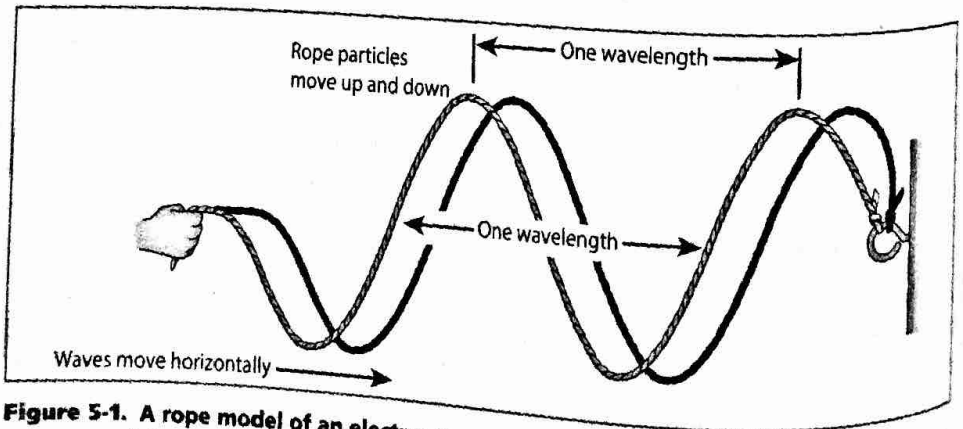

Figure 5-1. A rope model of an electromagnetic transverse wave: As particles of the rope move up and down, the wave moves along the length of the rope. In an electromagnetic wave, there are no moving particles. Instead, the wave vibrates at right angles to the direction in which the wave is moving.

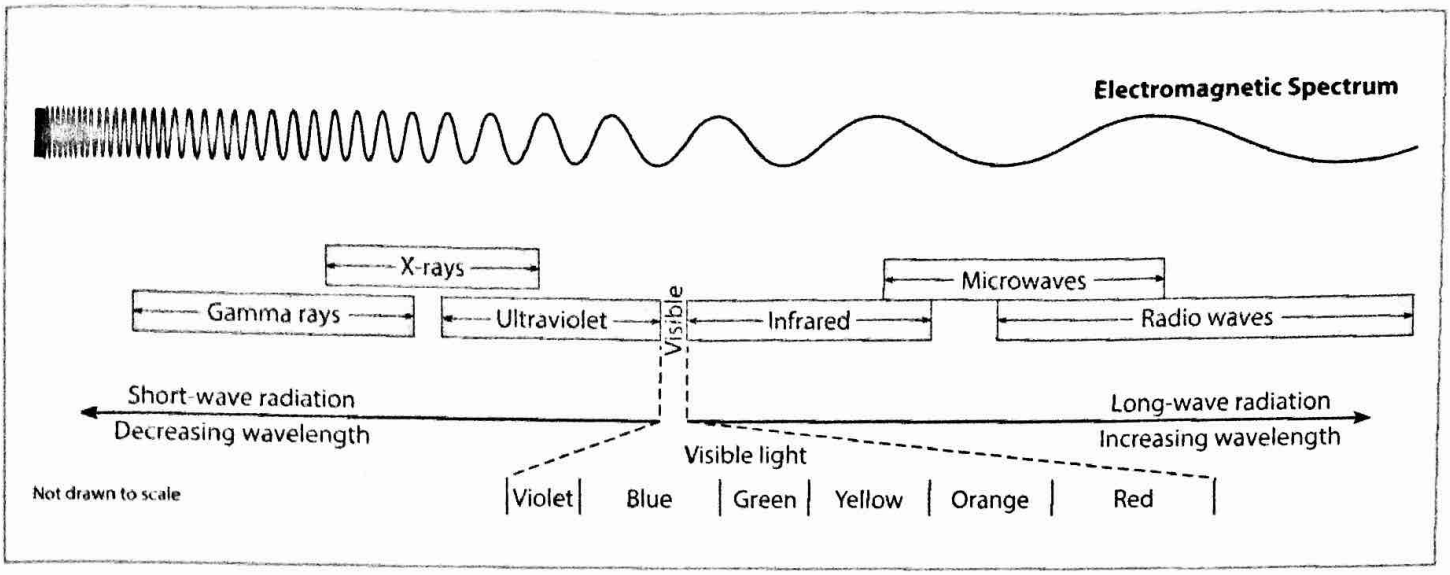

Figure 5-2. An electromagnetic spectrum. Also see a similar chart in the *Earth Science Reference Tables.* (R)

Characteristics and Types of Electromagnetic Energy

Different types of electromagnetic energy are distinguished by their different wavelengths. The **wavelength** is the distance from one crest of a wave to the next crest. A wavelength may also be described as the distance between any two corresponding points on successive cycles, as shown in Figure 5-1. Figure 5-2 shows the various types of electromagnetic energy in order of increasing wavelength. Any model that shows the types of electromagnetic energy is known as an **electromagnetic spectrum.**

Visible light is the only part of the electromagnetic spectrum that can be seen by the human eye. Infrared energy is often felt due to its heating effects. Instruments must be used to observe most forms of electromagnetic energy, including ultraviolet energy, which tans or burns the skin. Electromagnetic energy can be separated into two groups by comparing its wavelengths to those of visible light. Electromagnetic energy with a wavelength longer than visible light is called long-wave electromagnetic energy. Electromagnetic energy with a wavelength shorter than visible light is called a short wave. Some scientists include visible light as a type of short-wave radiation.

Interactions Between Electromagnetic Energy and an Environment

When electromagnetic energy comes in contact with a material, the waves interact with the material. The waves may be

- refracted, or bent, in their passage through materials of varying density so that the direction of the waves is changed
- reflected, or bounced off the material
- scattered, or refracted and/or reflected in various directions
- transmitted, or passed through the material
- absorbed, or taken into the material

Surface Properties and Absorption Characteristics of a surface determine the amount of electromagnetic energy that can be absorbed. For example, the darker the color of the surface of a material, the more visible light it will absorb. This is the reason that a dark-colored asphalt road feels hotter to the bare foot on a sunny day than a light-colored concrete road. Color is the way the human eye distinguishes the various wavelengths of visible light.

The **texture**—roughness or smoothness—of a surface also affects the amount of electromagnetic energy absorbed. The rougher a surface is, the more energy it will absorb and the less it will reflect. For example, mirrors are shiny because they are smooth and reflect most of the incoming visible light.

The more effective a material is at absorbing electromagnetic energy, the better it also is at radiating, or giving off, electromagnetic energy. Thus a dark-colored object will heat up quickly in sunlight, but it will also cool off quickly after sunset because it rapidly radiates electromagnetic energy. The result is that a concrete road will be warmer a few hours after sunset on a sunny day than will a road made of asphalt.

Review Questions

1. Which is the major source of energy for most of Earth's processes?
   (1) radioactive decay within Earth's interior
   (2) convection currents in Earth's mantle
   (3) radiation received from the sun
   (4) earthquakes along fault zones

2. All objects warmer than 0 Kelvin (absolute zero) must be
   (1) radiating electromagnetic energy
   (2) condensing to form a gas
   (3) warmer than 0°C
   (4) expanding in size

3. The various types of electromagnetic energy are distinguished from one another by their
   (1) temperature
   (2) wavelengths
   (3) height of waves
   (4) speed of travel in space

4. Which type of electromagnetic energy has the shortest wavelength?
   (1) ultraviolet
   (2) visible light
   (3) gamma rays
   (4) radio waves

5. In the visible spectrum, which color has the longest wavelength?
   (1) red
   (2) green
   (3) orange
   (4) violet

6. Which statement about electromagnetic energy is correct?
   (1) Violet light has a longer wavelength than red light.
   (2) X-rays have a longer wavelength than infrared waves.
   (3) Radio waves have a shorter wavelength than ultraviolet rays.
   (4) Gamma rays have a shorter wavelength than visible light.

7. As electromagnetic energy from a heat source interacts with its environment, it is being
   (1) reflected only
   (2) refracted only
   (3) absorbed only
   (4) reflected, refracted, and absorbed

8. When electromagnetic energy travels from air into water, the waves are bent due to the density differences between the air and water. What is this bending called?

9. Which would absorb the most solar radiation, if you assume that each covers an equal geographic area?
   (1) a freshwater lake
   (2) a snow field
   (3) a sandy beach
   (4) a forest

10. Which type of surface would most likely be the best reflector of electromagnetic energy?

(1) dark-colored and rough
(2) dark-colored and smooth
(3) light-colored and rough
(4) light-colored and smooth

11. An object that is a good radiator of electromagnetic waves is also a good

(1) insulator from heat
(2) reflector of heat
(3) absorber of electromagnetic energy
(4) refractor of electromagnetic energy

12. A homeowner decides to install carpet in a room that receives the most sunlight. A carpet with which characteristics will absorb the most radiation from the sun?

(1) smooth texture and light color
(2) smooth texture and dark color
(3) rough texture and light color
(4) rough texture and dark color