Electromagnetic Energy

1 Most of the electromagnetic energy radiated from Earth's surface is in the form of

(1) ultraviolet rays (3) gamma rays

(2) infrared rays (4) x rays

2 In which region of the electromagnetic spectrum is most of Earth's outgoing terrestrial radiation?

(1) infrared (3) ultraviolet

(2) visible (4) x rays

Base your answers to questions 3 on the passage and mineral table below and on your knowledge of Earth science. The table shows some properties of four minerals that display fluorescence.

Fluorescent Minerals

All minerals have the ability to reflect visible light. Only about 15% of minerals have an interesting physical property known as fluorescence. These minerals have the ability to temporarily absorb a small amount of electromagnetic energy and, an instant later, release a small amount of energy of a different wavelength. This change in wavelength causes a temporary color change of the mineral in the eye of an observer. The color change of fl uorescent minerals is most spectacular when the minerals are placed in darkness and exposed to electromagnetic energy shorter than visible light.

A former zinc mine in New Jersey is one of the most famous sources of fluorescent minerals in the entire world. Zincite and willemite were two of the zinc ores mined there. It was later discovered that more than 91 minerals in this region displayed fluorescence under shortwave electromagnetic energy.

Mineral	Hardness	Color Under Visible Light	"Fluorescent" Color	Composition
Calcite	3	clear-white-variable	bright orange	$CaCO_3$
Celestine	3 to 3.5	colorless-variable	yellow and/or white/blue	$SrSO_4$
Willemite	5.5	pink-tan	bright green	Zn_2SiO_4
Zincite	4	yellow-orange	yellow	ZnO

3 Which two forms of electromagnetic energy are used to produce the most spectacular fluorescence when placed in darkness?

(1) microwaves and x rays (3) ultraviolet and x rays

(2) microwaves and infrared (4) ultraviolet and infrared

Base your answers to questions 4 on the passage below and on your knowledge of Earth science.

Cosmic Microwave Background Radiation

In the 1920s, Edwin Hubble's discovery of a pattern in the red shift of light from galaxies moving away from Earth led to the theory of an expanding universe. This expansion implies that the universe was smaller, denser, and hotter in the past. In the 1940s, scientists predicted that heat (identified as cosmic microwave background radiation) left over from the Big Bang would fill the universe. In the 1960s, satellite probes found that cosmic microwave background radiation fills the universe uniformly in every direction, and indicated a temperature of about 3 kelvins (K). This radiation has been cooling as the universe has been expanding.

4 Cosmic microwave background radiation is classified as a form of electromagnetic energy because it

(1) travels in waves through space

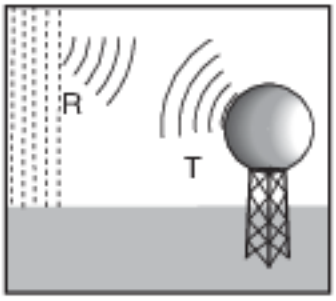
(2) moves faster than the speed of light

(3) is visible to humans

(4) moves due to particle collisions

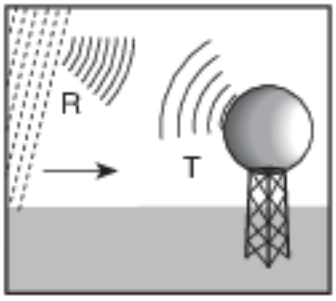
Base your answers to questions 5 on the diagrams below and on your knowledge of Earth science. The diagrams represent electromagnetic waves being transmitted (T) by a Doppler radar weather instrument and waves being reflected (R) by rain showers. This instrument produces computer images that show the movement of rainstorms.

A Stationary Rain Shower



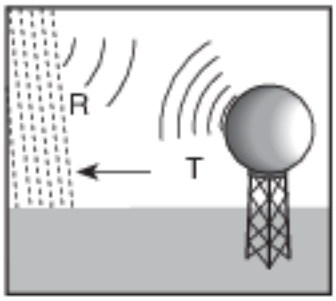
The reflected wavelengths (*R*) from a stationary rain shower are equal to the transmitted wavelengths (*T*).

A Rain Shower Moving Toward the Instrument



The reflected wavelengths (*R*) from a rain shower moving toward the instrument are shorter than the transmitted wavelengths (*T*).

A Rain Shower Moving Away from the Instrument



The reflected wavelengths (*R*) from a rain shower moving away from the instrument are longer than the transmitted wavelengths (*T*).

5 This Doppler radar instrument transmits electromagnetic energy in the form of microwaves. Some microwave wavelengths are between the wavelengths of

(1) gamma rays and x rays
(2) infrared and radio waves
(3) ultraviolet and infrared
(4) x rays and ultraviolet

6 Which type of electromagnetic radiation has the shortest wavelength?

(1) ultraviolet
(2) gamma rays
(3) radio waves
(4) visible light

7 Most of which type of electromagnetic radiation is given off by Earth's surface at night?

(1) gamma rays (3) visible light

(2) ultraviolet light (4) infrared rays

8 In which portion of the electromagnetic spectrum is the maximum intensity of Earth's outgoing radiation?

(1) visible light (3) infrared

(2) gamma rays (4) ultraviolet

9 Which type of electromagnetic radiation listed below has the longest wavelength?

(1) infrared (3) red visible light

(2) ultraviolet (4) violet visible light

Base your answers to questions 10 on the data table below and on your knowledge of Earth science. The data table shows how the destruction of the ozone layer in Earth's atmosphere has affected the amount of ultraviolet radiation reaching Earth's surface beneath the areas of ozone destruction.

Ozone Loss and Ultraviolet Radiation

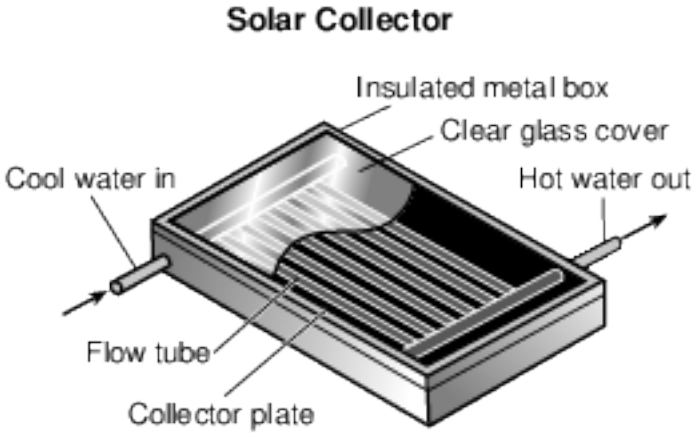
Ozone Destruction (%)	Average Increase in Ultraviolet Radiation Reaching Earth's Surface (%)
0	0
5	5
10	12
15	20
20	28
25	36
30	47
35	60
40	76

10 On the table in the image provided, place one check mark in each row to compare the relative wavelengths of other types of electromagnetic radiation to ultraviolet (UV) radiation. [1]

Wavelength Comparison to Ultraviolet (UV) Radiation

Type of Electromagnetic Radiation	All Wavelengths Shorter Than UV	All Wavelengths Longer Than UV	Some Wavelengths Shorter and Some Wavelengths the Same as UV
Gamma Rays			
Microwaves			
Visible light			
X rays			

Base your answers to questions 11 on the diagram below and on your knowledge of Earth science. The diagram represents a cutaway view of a flat-plate solar collector used to heat water at a New York State location.



11 Explain why the flow tubes and collector plate inside the solar collector are black in color. [1]

Answer Keys

1 2

2 1

3 3

4 1

5 2

6 2

7 4

8 3

9 1

10 Allow 1 credit for a correctly completed chart as shown below.

- **Note:** Allow credit if a symbol other than a check mark is used.

Wavelength Comparison to Ultraviolet (UV) Radiation

Type of Electromagnetic Radiation	All Wavelengths Shorter Than UV	All Wavelengths Longer Than UV	Some Wavelengths Shorter and Some Wavelengths the Same as UV
Gamma Rays	✓		
Microwaves		✓	
Visible light		✓	
X rays			✓

11 Allow 1 credit. Acceptable responses include, but are not limited to:

- — Black is a good absorber of electromagnetic energy/sunlight/insolation.
- — Black is a good absorber and a good radiator.
- — Dark colors take in radiation better than light colors.
- — Black absorbs more energy.
- Note: Do not allow credit for “black absorbs energy” alone because all colors absorb energy. Black
- is just a better absorber of that energy.