

Chapter 2

Warming the Earth and the Atmosphere

Multiple Choice Exam Questions

1. Which of the following provides a measure of the average speed of air molecules?
- pressure
 - temperature
 - density
 - heat

ANSWER: b

2. A change of one degree on the Celsius scale is ___ a change of one degree on the Fahrenheit scale.
- equal to
 - larger than
 - smaller than
 - is in the opposite direction of

ANSWER: b

3. The temperature scale that sets freezing of pure water at 32°.
- Kelvin
 - Fahrenheit
 - Celsius
 - British

ANSWER: b

4. The transfer of heat by molecule-to-molecule contact is
- conduction.
 - convection.
 - radiation.
 - ultrasonic.

ANSWER: a

5. Which of the following is the poorest conductor of heat?
- still air
 - water
 - ice
 - snow
 - soil

ANSWER: a

6. The horizontal transport of any atmospheric property by the wind is called
- advection.
 - radiation.
 - conduction.
 - latent heat.
 - reflection.

ANSWER: a

7. Heat transferred upward from the surface of the *moon* can take place by
- convection.
 - conduction.
 - latent heat.
 - radiation.

ANSWER: d

8. Which of the following is *not* a heat-transport process in the atmosphere?
- conduction
 - radiation
 - convergence
 - convection

ANSWER: c

9. A heat transfer process in the atmosphere that depends upon the movement of air is
- conduction.
 - reflection.
 - convection.
 - radiation.

ANSWER: b

10. Snow will usually *melt* on the roof of a home that is a
- good radiator of heat.
 - good conductor of heat.
 - poor radiator of heat.
 - poor conductor of heat.

ANSWER: b

11. The heat energy released when water vapor changes to a liquid is called
- latent heat of evaporation.
 - latent heat of fusion.
 - latent heat of fission.

d. latent heat of condensation.

ANSWER: d

12. This process causes rising air to cool.
- a. expansion
 - b. evaporation
 - c. compression
 - d. condensation

ANSWER: a

13. The cold feeling that you experience after leaving a swimming pool on a hot, dry, summer day is
- a. heat transport by conduction.
 - b. heat transport by convection.
 - c. heat transport by radiation.
 - d. heat transport by latent heat.

ANSWER: d

14. The temperature of a rising air parcel
- a. always cools due to expansion.
 - b. always warms due to expansion.
 - c. always cools due to compression.
 - d. always warms due to compression.
 - e. remains constant.

ANSWER: a

15. Energy transferred by electromagnetic waves is called
- a. magnetism.
 - b. convection.
 - c. conduction.
 - d. radiation.

ANSWER: d

16. The proper order from shortest to longest wavelength is
- a. visible, infrared, ultraviolet.
 - b. infrared, visible, ultraviolet.
 - c. ultraviolet, visible, infrared.
 - d. visible, ultraviolet, infrared.
 - e. ultraviolet, infrared, visible.

ANSWER: c

17. Electromagnetic radiation with wavelengths between 0.4 and 0.7 micrometers is called
- a. ultraviolet light.
 - b. visible light.
 - c. infrared light.
 - d. microwaves.

ANSWER: b

18. Solar radiation reaches the earth's surface as
- a. visible radiation only.
 - b. ultraviolet radiation only.
 - c. infrared radiation only.
 - d. visible and infrared radiation only.
 - e. ultraviolet, visible, and infrared radiation.

ANSWER: e

19. The earth's radiation is often referred to as ___ radiation, while the sun's radiation is often referred to as ___ radiation.
- a. shortwave, longwave
 - b. shortwave, shortwave
 - c. longwave, shortwave
 - d. longwave, longwave

ANSWER: c

20. The earth emits radiation with greatest intensity at
- a. infrared wavelengths.
 - b. radio wavelengths.
 - c. visible wavelengths.
 - d. ultraviolet wavelengths.

ANSWER: a

21. When we see the moon at night, we are seeing
- a. visible light emitted by the moon.
 - b. infrared light emitted by the moon.
 - c. visible light reflected by the moon.
 - d. infrared light reflected by the moon.

ANSWER: c

22. Which of the following determine the kind (wavelength) and amount of radiation that an object emits?
- a. temperature
 - b. thermal conductivity

- c. density
- d. latent heat

ANSWER: a

23. The rate at which radiant energy is emitted by a body
- a. increases with increasing temperature.
 - b. increases with decreasing temperature.
 - c. does not depend on the temperature.
 - d. depends on the chemical composition of the body.

ANSWER: a

24. This property of electromagnetic radiation is inversely proportional to temperature; if temperature increases ___ will decrease.
- a. propagation speed
 - b. intensity
 - c. rate of emission
 - d. wavelength of peak emission

ANSWER: d

25. Which of the following is known primarily as a selective absorber of *ultraviolet* radiation?
- a. carbon dioxide
 - b. ozone
 - c. water vapor
 - d. clouds

ANSWER: b

26. Which of the following statements is *not* correct?
- a. calm, cloudy nights are usually warmer than calm, clear nights
 - b. each year the earth's surface radiates away more energy than it receives from the sun
 - c. the horizontal transport of heat by the wind is called advection
 - d. good absorbers of radiation are usually poor emitters of radiation

ANSWER: d

27. The atmospheric greenhouse effect is due primarily to the fact that
- a. oxygen and ozone absorb ultraviolet radiation.
 - b. nitrogen and oxygen transmit visible radiation.
 - c. cloud formation releases latent heat energy.
 - d. carbon dioxide and water vapor absorb infrared radiation.

ANSWER: d

28. The atmospheric greenhouse effect is produced mainly by the
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- a. absorption and re-emission of visible light by the atmosphere.
- b. absorption and re-emission of ultraviolet radiation by the atmosphere.
- c. absorption and re-emission of infrared radiation by the atmosphere.
- d. absorption and re-emission of visible light by clouds.
- e. absorption and re-emission of visible light by the ground.

ANSWER: c

29. Without the atmospheric greenhouse effect, the average surface temperature would be
- a. higher than at present.
 - b. lower than at present.
 - c. the same as it is now.
 - d. much more variable than it is now.

ANSWER: b

30. Clouds ___ infrared radiation and ___ visible radiation.
- a. absorb, absorb
 - b. absorb, reflect
 - c. reflect, reflect
 - d. reflect, absorb

ANSWER: b

31. The albedo of the earth's surface is only about 4%, yet the combined albedo of the earth and the atmosphere is about 30%. Which set of conditions below *best* explains why this is so?
- a. high albedo of clouds, low albedo of water
 - b. high albedo of clouds, high albedo of water
 - c. low albedo of clouds, low albedo of water
 - d. low albedo of clouds, high albedo of water

ANSWER: a

32. The albedo of the moon is 7%. This means that
- a. 7% of the sunlight striking the moon is reflected.
 - b. 7% of the sunlight striking the moon is absorbed.
 - c. the moon emits only 7% as much energy as it absorbs from the sun.
 - d. 93% of the sunlight striking the moon is reflected.

ANSWER: a

33. About 50% of the sunlight reaching the top of the atmosphere is
- a. absorbed by ozone in the stratosphere.
 - b. reflected or scattered by air molecules and clouds.
 - c. absorbed at the ground.
 - d. absorbed by greenhouse gases.

ANSWER: c

34. The major process that warms the lower *atmosphere* is
- the release of latent heat during condensation.
 - conduction of heat upward from the surface.
 - convection.
 - absorption of infrared radiation.
 - direct absorption of sunlight by the atmosphere.

ANSWER: d

35. If the amount of energy lost by the earth to space each year were not approximately equal to that received ,
- the atmosphere's average temperature would change.
 - the length of the year would change.
 - the sun's output would change.
 - the mass of the atmosphere would change.

ANSWER: a

36. The atmosphere near the earth's surface is "heated from below." Which of the following contributes the smallest amount of energy?
- conduction of heat upward from a hot surface
 - convection from a hot surface
 - absorption of infrared energy that has been radiated from the surface
 - heat energy from the earth's interior

ANSWER: d

37. Which of the following processes transports, on average, the most energy from the ground to the atmosphere?
- convection
 - conduction
 - radiation
 - latent heat

ANSWER: c

38. Incoming solar radiation in middle latitudes is less in winter than in summer because
- the sun's rays slant more and spread their energy over a larger area.
 - there is a decrease in carbon dioxide levels in the atmosphere.
 - the cold dense air lowers the intensity of the sun's rays.
 - the earth is furthest from the sun.

ANSWER: a

39. The earth is closest to the sun in
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- a. January
- b. March
- c. July
- d. September

ANSWER: a

40. Which of the following is one of the main causes of the seasons?
- a. the changing distance between the earth and the sun
 - b. a periodic reversal in global scale air circulation patterns
 - c. the length of the daylight hours
 - d. land/ocean temperature contrasts

ANSWER: c

41. At the time of the winter solstice in the Northern Hemisphere
- a. astronomical winter begins in the Northern Hemisphere.
 - b. the noon sun is over latitude 23.5° S.
 - c. at middle latitudes in the Northern Hemisphere, this marks the longest night of the year.
 - d. all of the above

ANSWER: d

42. Which of the following helps to explain why even though northern latitudes experience 24 hours of sunlight on June 22, they are not warmer than latitudes further south?
- a. solar energy is spread over a larger area in northern latitudes
 - b. some of the sun's energy is reflected by snow and ice in the northern latitudes
 - c. increased cloud cover reflects solar energy in the northern latitudes
 - d. solar energy is used to melt frozen soil in the northern latitudes
 - e. all of the above

ANSWER: e

43. Between Christmas and New Year's, at middle latitudes in the Northern Hemisphere, the length of the day
- a. increases.
 - b. decreases.
 - c. does not change.
 - d. is 12 hours long.

ANSWER: a

44. On which date would the sun's rays be closest to being perpendicular to the earth's surface in the middle latitudes of the Northern Hemisphere?
- a. March 21
 - b. June 21
 - c. July 1

- d. July 21
- e. August 1

ANSWER: b

45. The sun will pass directly overhead at noon in Miami, Florida (latitude 26° N)
- a. once a year.
 - b. twice a year.
 - c. four times a year.
 - d. never.

ANSWER: d

46. When it is January and winter in the Northern Hemisphere, it is ___ and ___ in the Southern Hemisphere.
- a. January and summer
 - b. January and winter
 - c. July and winter
 - d. July and summer

ANSWER: a

47. For maximum winter warmth, in the Northern Hemisphere, large windows in a house should face
- a. north.
 - b. south.
 - c. east.
 - d. west.

ANSWER: b

48. Although the polar regions radiate away more heat energy than they receive by insolation in the course of a year, they are prevented from becoming progressively colder each year by the
- a. conduction of heat through the interior of the earth.
 - b. concentration of earth's magnetic field lines at the poles.
 - c. circulation of heat by the atmosphere and oceans.
 - d. the insulating properties of snow.
 - e. release of latent heat to the atmosphere when polar ice melts.

ANSWER: c

49. The most important reason why summers in the Southern Hemisphere are not warmer than summers in the Northern Hemisphere is that
- a. the earth is closer to the sun in January.
 - b. the earth is farther from the sun in July.
 - c. over 80% of the Southern Hemisphere is covered with water.
 - d. the sun's energy is less intense in the Southern Hemisphere.

ANSWER: c

50. In the middle latitudes of the Northern Hemisphere, the day with the shortest number of daylight hours occurs around
- a. June 22.
 - b. December 22.
 - c. September 23.
 - d. January 1.
 - e. February 15.

ANSWER: b

True False Exam Questions

1. The formation of frost (deposition) releases heat and warms the surroundings.
(ans: TRUE)
2. Microwave radiation has a longer wavelength and is a more energetic form of radiation than visible light.
(ans: FALSE)
3. Virtually all the UV-C radiation, which is more harmful than UV-A or UV-B, is absorbed by ozone in the stratosphere.
(ans: TRUE)
4. The atmosphere is essentially completely transparent to electromagnetic radiation.
(ans: FALSE)
5. If our eyes responded to infrared radiation instead of visible light, clouds would appear black because they are good absorbers of IR.
(ans: TRUE)
6. Because air molecules are so small, compared to the wavelength of light, air does not scatter or absorb incoming sunlight.
(ans: FALSE)
7. Satellite data from the *Earth Radiation Budget Experiment (ERBE)* indicate that the overall effect of clouds is to cool the earth's climate.
(ans: TRUE)
8. The earth's surface receives nearly twice as much longwave IR energy from the atmosphere as it does shortwave radiation from the sun.
(ans: TRUE)
9. The Southern Hemisphere has warmer summers and colder winters than the Northern Hemisphere.
(ans: FALSE)
10. On a hot day, you are likely to stay cooler if you wear a white shirt.
(ans: TRUE)

Word Choice Exam Questions

1. If you could somehow see the random motions of the atoms and molecules in air, would they all be moving at the SAME or at DIFFERENT speeds? (circle one answer)
(ans: DIFFERENT)
2. About 44% of the energy emitted by the sun is visible light. Most of the remaining radiation falls in the INFRARED ULTRAVIOLET portion of the spectrum. (circle one answer)
(ans: INFRARED)
3. If the earth's average surface temperature were to increase, the amount of radiation emitted from the earth's surface would INCREASE DECREASE and the wavelength of peak emission would shift toward LONGER SHORTER wavelengths. (choose one word from each pair)
(ans: INCREASE, SHORTER)
4. A "window" is a wavelength region where the atmosphere TRANSMITS ABSORBS EMITS radiant energy. (circle one answer)
(ans: TRANSMITS)
5. Overcast skies usually result in WARMER COOLER daytime temperatures because clouds are good REFLECTORS ABSORBERS of VISIBLE INFRARED light. (choose one word from each pair)
(ans: COOLER, REFLECTORS, VISIBLE)
6. Generally speaking, to see the aurora you must be located at high ALTITUDE LATITUDE.
(circle one answer)
(ans: LATITUDE)
7. Compared to Phoenix (30° N latitude), Minneapolis (45° N) will have LONGER SHORTER days in the winter and LONGER SHORTER days in the summer. (choose one word from each pair)
(ans: SHORTER, LONGER)
8. In a positive water vapor-temperature feedback process, warming will result in INCREASED DECREASED atmospheric water vapor concentrations which will STRENGTHEN WEAKEN the greenhouse effect. (choose one word from each pair)
(ans: INCREASED, STRENGTHEN)
9. High latitudes lose MORE, LESS, the SAME amount of energy to space as(than) they receive from the sun.(circle one answer)
(ans: MORE)
10. The earth ALWAYS SOMETIMES receives solar radiation and ALWAYS SOMETIMES emits infrared radiation (circle one answer)
(ans: SOMETIMES, ALWAYS)

Short Answer Exam Questions

- _____ provides a measure of the average speed or kinetic energy of the atoms or molecules in air.
(ans: TEMPERATURE)
- Fill in the blanks below using one of the following choices: 0° F, 0° C, 100 °F, 100° C (choices may be used more than once or not at all).
 - boiling point of water (sea level) _____
 - hottest temperature listed _____
 - coldest temperature listed _____
 - melting point of ice _____(ans: a. 100°C, b. 100°F, c. 0° F, d. 0°C)
- Ocean currents transport energy in the form of warm ocean water from the tropical oceans to higher latitudes. This is an example of the _____ energy transport process?
(ans: CONVECTION or ADVECTION)
- _____ originates from rapidly vibrating electrons which exist in every object.
(ans: ELECTROMAGNETIC RADIATION)
- In some situations light behaves as if it were composed of particles rather than having a wavelike nature. What is the name given to light "particles?"
(ans: PHOTONS)
- What important ability or property does electromagnetic radiation have that other energy transport processes, such as conduction and convection, do not?
(ans: Radiation can propagate through empty space.)
- Which of the processes listed at right transports the most energy from the earth to the atmosphere? Which process transports the least amount of energy? What important process is missing from the list?

conduction
convection
radiation

(ans: most - RADIATION, least - CONDUCTION, missing - LATENT HEAT)
- What is the name given to the stream of charged particles that travels outward from the sun?
(ans: SOLAR WIND)
- A faint glow known as the _____ can be seen at high latitudes when charged particles from the sun collide with atmospheric gases causing them to emit visible light.
(ans: AURORA)
- The fur of a polar bear is a(n) _____ absorber of visible light.
(ans: POOR)

Essay Exam Questions

1. Using the concept of latent heat, explain why perspiration is an effective way of reducing a person's body temperature.
2. Using energy transfer concepts, explain why wearing a heavy down jacket keeps you warm on a cold winter day.
3. Why does air warm when it sinks?
4. Why does the southern hemisphere winter occur at the same time as the northern hemisphere summer?
5. Does the expansion of air cause the its temperature to increase or decrease? Why?
6. In the discussion of the earth's annual energy balance we saw that the earth absorbed approximately 51 units of solar energy but emitted 117 units of infrared energy. What prevents the earth from getting colder and colder?
7. Will a rising parcel of air always expand? Why?
8. Describe and give examples of the various ways that heat can be transported in the atmosphere.
9. Explain how energy in the form of sunlight absorbed at the ground could be transferred upward in the atmosphere in the form of latent heat. How or when is the latent heat energy released in the air above the ground?
10. What is meant by the term "positive feedback?" What role could positive feedback play in the atmospheric greenhouse effect? Would this enhance or reduce global warming? Can you think of any "negative feedback" mechanisms?
11. The moon is located at about the same distance from the sun as the earth. How would you expect surface temperatures on the moon to compare with the earth? (you can assume that the moon has the same average albedo as the earth)
12. Describe the atmospheric greenhouse effect. Is there any difference between the way the atmospheric greenhouse effect works on a clear night and on a cloudy night?
13. Several of the planets in our solar system are further from the sun and cooler than the earth. Do they emit electromagnetic radiation? Why are we able to see the planets in the sky at night?
14. How could increased cloud cover cause an increase in the average surface temperature? How could increased cloudiness cause a decrease in average surface temperatures?
15. When you remove a cold beverage from a refrigerator in a humid room, water vapor will condense on the sides of the container. Would this act to warm or cool the beverage, or would the condensation have no effect on the beverage's temperature?

16. Imagine that the temperature of the sun were to change. Describe or discuss some of the effects that this might have on the earth's energy budget and the earth's climate. How might it affect the weather where you live?
17. Describe the seasons that you would experience at two widely different points on the earth. How do you think seasonal changes can influence a region's culture and traditions?
18. Many automobile engines are cooled by water which flows in a closed circuit through the engine block and the car's radiator. How many different heat transport processes do you find in operation here?
19. Many people will blow on a bowl of hot soup to try to cool it. In your view, what are the two most important heat transport processes cooling the soup?
20. What are the other factors, besides increasing CO₂ concentrations, that affect global warming?