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Indicate the answer choice that best completes the statement or answers the question.

1. Two objects have the same temperature. Object A feels colder to the touch than object B. Which of the following properties may explain this difference between the two objects?
   a. latent heat
   b. thermal conductivity
   c. specific heat
   d. density

2. Which of the following regions of the spectrum represent the Earth's atmospheric window?
   a. infrared region
   b. polar regions
   c. visible region
   d. ultraviolet region

3. Which of the following terms refers to the change of state of ice into water vapour?
   a. sublimation
   b. condensation
   c. crystallization
   d. melting

4. Which of the following statements describes what would happen if the amount of energy lost each year by the Earth to space were not approximately equal to that received?
   a. The sun's output would change.
   b. The length of the year would change.
   c. The atmosphere's average temperature would change.
   d. The mass of the atmosphere would change.

5. Which of the following percentages represents the approximate combined albedo of the Earth and the atmosphere?
   a. 50%
   b. 30%
   c. 10%
   d. 4%

6. Which of the following terms refers to the amount of heat energy required to bring about a small change in temperature?
   a. radiative equilibrium
   b. dead heat
   c. latent heat
   d. specific heat

7. Which of the following defines the term *latent*?
   a. hidden
   b. dense

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c. light
d. hot

8. As air in the figure below moves from A to B, what will happen to its volume?

a. It will increase.
b. It will decrease.
c. It will decrease at first, and then increase.
d. It will remain the same.

9. Which of the following terms refers to the luminous surface of the sun?

a. corona
b. photosphere
c. chromosphere
d. thermosphere

10. At which of the following temperatures does the Earth radiate energy at the greatest rate or intensity?

a. –40°C
b. 32°C
c. 60°C
d. 105°C

11. The albedo of the Earth's surface is about 4 percent, yet the combined albedo of the Earth and the atmosphere is about 30 percent. Which of the following conditions **BEST** explains why this is the case?

a. low albedo of clouds, low albedo of water
b. high albedo of clouds, low albedo of water
c. low albedo of clouds, high albedo of water
d. high albedo of clouds, high albedo of water

12. Which of the following terms refers to the change of state of water from a liquid to a vapour?

a. condensation
b. evaporation
c. freezing
d. sublimation

13. As you walk across a sandy beach on a summer day, the bottoms of your feet become extremely hot. This is an example of which type of heat transfer?

a. radiation
b. ultrasonic
c. conduction

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d. convection

14. Of the following measurements, which is the longest?
    a. 3000 micrometres
    b. 25 mm
    c. 2 cm
    d. 10^{-3} m

15. In which of the following forms is most of the radiation emitted by the human body?
    a. visible radiation, but too weak to be visible
    b. invisible ultraviolet radiation
    c. invisible gamma radiation
    d. invisible infrared radiation

16. Why does an air parcel become cooler as it rises and expands?
    a. The air pressure around the parcel increases as it rises.
    b. As molecules push outward to expand the parcel the parcel loses energy.
    c. Water vapour in the parcel evaporates as it rises.
    d. The density of the air parcel decreases as it rises.

17. Which of the following processes occurs when rising air cools?
    a. compression
    b. condensation
    c. evaporation
    d. expansion

18. Which of the following is the poorest conductor of heat?
    a. soil
    b. water
    c. snow
    d. still air

19. City A is located on the shoreline of a large body of water. City B is located 100 km inland from the same body of water. In this scenario, which of the following statements is the most likely?
    a. City A will have warmer temperatures in summer.
    b. City B will have colder temperatures in winter.
    c. The two cities will have similar temperatures only in summer.
    d. The two cities will have similar temperatures in both summer and winter.

20. Which of the following statements explains why low clouds slow surface cooling at night better than clear skies do?
    a. Clouds start convection currents among them.
    b. Water droplets in the clouds reflect infrared energy back to the Earth.
    c. Clouds absorb and radiate infrared energy back to the Earth.

d. Clouds conduct heat better than clear night air does.

21. Suppose you are outside wearing a winter coat in very cold temperature, and the coat keeps you quite warm. Which of the following describes the reason that you keep warm?

a. The coat generates a temperature gradient between your body and the surrounding air.
b. The coat is the source of the heat that keeps you warm.
c. The coat absorbs heat from the sun.
d. The coat has insulating properties that keeps you warm.

22. Which of the following defines Earth's radiative equilibrium temperature?

a. the average temperature Earth must maintain to prevent the oceans from freezing solid
b. the temperature at which solar radiation and infrared radiation are absorbed at equal rates
c. the temperature at which the Earth radiates energy at maximum intensity
d. the temperature at which rates of evaporation and condensation on the Earth are in balance

23. As air in the figure above moves from A to B, what will happen to its temperature?

a. It will decrease.
b. It will decrease at first, and then increase.
c. It will increase.
d. It will remain the same.

24. Which of the following processes can occur when heat is transferred outward from the surface of the moon?

a. latent heat
b. convection
c. conduction
d. radiation

25. When you touch a wooden chair and a glass table top in the same room, the glass feels cooler. Why?

a. The chair is warmer.
b. Glass has a higher specific heat than wood.
c. Latent heat is being transferred from the glass to your skin.
d. Glass is a better conductor of heat than wood.

26. According to the Stefan-Boltzmann law, which of the following statements expresses the radiative energy emitted by one square metre of an object?

a. It is equal to a constant multiplied by its temperature, raised to the negative third power.
b. It is equal to a constant multiplied by its temperature, raised to the second power.
c. It is equal to a constant multiplied by its temperature, raised to the fourth power.
d. It is equal to a constant multiplied by its temperature, raised to the tenth power.

27. Which of the following is primarily known as a selective absorber of ultraviolet radiation?

a. water vapour
b. carbon dioxide
c. clouds

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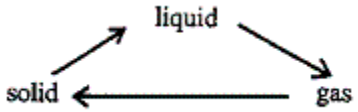
d. ozone

28. Which of the following statements describes the difference between red and blue light?
   a. Red and blue light have different directions of polarization.
   b. The wavelength of red light is longer.
   c. Blue light has a higher speed of propagation.
   d. Red light has a higher intensity.

29. Referring to the figure below, how many of the phase changes release energy to the surroundings?



a. all
b. one
c. none
d. two

30. Which of the following is the range of wavelengths corresponding to the maximum amount of radiation emitted by the Earth?
   a. 0.5 micrometre 10 micrometers
   b. 1 micrometre 1 micrometer
   c. 10 micrometres 30 micrometers
   d. 30 micrometres 0.5 micrometers

31. Suppose the absolute temperature of an object doubles. By which of the following factors will the maximum energy emitted increase?

a. 16
b. 4
c. 2
d. 8

32. How much radiant energy will an object emit if its temperature is at absolute zero?
   a. none
   b. the same as at any other temperature
   c. It depends on the object's chemical composition
   d. the maximum theoretical amount

33. Suppose last night was clear and calm and tonight there will be low clouds. Which of the following can be predicted about tonight's minimum temperature?
   a. It will be higher than last night's minimum temperature.
   b. It will be above freezing.
   c. It will be the same as last night's minimum temperature.
   d. It will be lower than last night's minimum temperature.

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34. Which of the following processes makes perspiration cool the body?
    a. advective heat transfer
    b. latent heat transfer
    c. radiative heat transfer
    d. conductive heat transfer

35. Before a cold winter night in Florida a citrus farmer chooses to sprinkle his fruit with water in order to warm the fruit so it survives the night. Which of the following processes explains why this strategy warms the fruit?
    a. latent heat of evaporation
    b. latent heat of condensation
    c. latent heat of evaporation
    d. latent heat of deposition

36. Which of the following is the term often used to describe the form of radiation emitted by the sun?
    a. microwave
    b. shortwave
    c. gamma
    d. longwave

37. Which of the following refers to the main process that warms the lower atmosphere?
    a. conduction of heat upward from the surface
    b. release of latent heat during condensation
    c. absorption of infrared radiation
    d. direct absorption of sunlight by the atmosphere

38. Which of the following is the term often used to describe the form of radiation emitted by the Earth?
    a. shortwave
    b. longwave
    c. gamma
    d. microwave

39. Which of the following gases are mainly responsible for the atmospheric greenhouse effect in the Earth's atmosphere?
    a. water vapour and carbon dioxide
    b. ozone and oxygen
    c. nitrogen and carbon dioxide
    d. oxygen and nitrogen

40. The recorded air temperature the night after a heavy snowfall is much lower than the previous night despite a similar air mass being in place for both nights. What is the best explanation for this change in air temperature?
    a. Snow is a poor conductor of heat.
    b. Snow is a poor reflector of heat.
    c. Snow is a poor radiator of heat.
    d. Snow has a low albedo.

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41. Which of the following statements describes the radiative behaviour of clouds?
    a. They absorb visible radiation.
    b. They absorb infrared radiation.
    c. They absorb gamma radiation.
    d. They reflect ultraviolet radiation.

42. Before sunrise on a clear, calm, cold morning, frost can often be seen on the tops of parked cars, even when the air temperature is above freezing. Which of the following processes cools the tops of the cars and causes this condition?
    a. conduction
    b. convection
    c. latent heat
    d. radiation

43. Which of the following methods would keep an object cool even when it is exposed to direct sunlight?
    a. Wrap it in aluminum foil with the shiny side facing inward.
    b. Wrap it in black paper.
    c. Wrap it in aluminum foil with the shiny side facing outward.
    d. Put it in a brown paper bag.

44. Which of the following properties determines the kind (wavelength) and amount of radiation that an object emits?
    a. temperature
    b. latent heat
    c. density
    d. thermal conductivity

45. Which of the following terms refers to the heat transfer process in the atmosphere that depends upon the movement of air?
    a. conduction
    b. absorption
    c. convection
    d. radiation

46. Solar radiation reaches the Earth's surface in which of the following forms of radiation?
    a. ultraviolet, visible, and infrared
    b. gamma rays
    c. X-rays
    d. microwave

47. One micrometre is equal to which of the following units of length?
    a. one millionth of a metre
    b. one thousandth of a metre
    c. one hundredth of a metre
    d. one tenth of a millimetre

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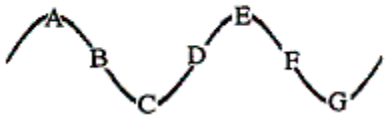
48. Which of the following gives the name for electromagnetic radiation that has wavelengths between 0.4 and 0.7 micrometres?

a. visible light
b. infrared light
c. microwaves
d. ultraviolet light

49. Which of the following expresses how far points A and C are apart?



a. 1 wavelength apart
b. 1/4 wavelength apart
c. 1/3 wavelength apart
d. 1/2 wavelength apart

50. Which of the following would happen to the Earth's radiative equilibrium temperature if the sun suddenly began emitting more energy?

a. It would decrease.
b. It would remain the same.
c. It would increase.
d. It would begin to oscillate.

51. Rain falling from clouds refers to which of the following forms of energy?

a. kinetic
b. potential
c. latent heat
d. radiant

52. Which of the following terms refers to the energy of motion?

a. kinetic energy
b. dynamic energy
c. static energy
d. sensible heat energy

53. On a warm summer day, what is the best colour of T-shirt to wear in order to best keep you cool?

a. red
b. blue
c. black
d. white

54. A good absorber of a given wavelength of radiation is also a good emitter of that wavelength. Which of the following

principles does this statement refer to?

a. first law of thermodynamics
b. Wien's law
c. Kirchhoff's law
d. Stefan-Boltzmann's law

55. Which of the following changes in radiative equilibrium temperature accompanies an increase in albedo?

a. no change
b. unstable oscillations
c. an increase
d. a decrease

56. In which of the following regions of the spectrum does the sun emit its greatest intensity of radiation?

a. infrared region
b. visible region
c. ultraviolet region
d. X-ray region

57. If the Earth's average surface temperature were to increase, how would this affect the wavelength of peak emission?

a. It would shift toward shorter wavelengths.
b. It would shift toward longer wavelengths.
c. It would shift toward longer wavelengths at first, and then toward shorter wavelengths.
d. It would not change.

58. Which of the following statements describes the relation between low clouds at night and the atmospheric greenhouse effect?

a. They weaken the atmospheric greenhouse effect.
b. They are caused by the atmospheric greenhouse effect.
c. They enhance the atmospheric greenhouse effect.
d. They have no effect on the atmospheric greenhouse effect.

59. Two objects, A and B, have the same mass but the specific heat of A is larger than B. Which of the following scenarios is more likely if both objects absorb equal amounts of energy?

a. A will become warmer than B.
b. A will get warmer, but B will get colder.
c. Both A and B will warm at the same rate.
d. B will become warmer than A.

60. At which time does sunlight pass through a thicker portion of the atmosphere?

a. sunrise and sunset
b. sunset and night
c. noon and night
d. sunrise and noon

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61. Referring to the figure above, which transfer of heat is being represented?

a. radiation
b. conduction
c. convection
d. scattering

62. Which of the following is the term for the heat transport that occurs when a hot air balloon is able to rise from a heat source below?

a. conduction
b. radiation
c. latent heat
d. convection

63. Which of the following statements is true about a black object?

a. It has a high albedo and is a poor absorber of visible radiation.
b. It has a high albedo and is a good absorber of visible radiation.
c. It has a low albedo and is a poor absorber of radiation.
d. It has a low albedo and is a good absorber of radiation.

64. Suppose the present concentration of CO_2 doubled in 100 years, and climate models predicted a 5^oC increase in Earth's average temperature. Which of the following gases must also increase in concentration?

a. oxygen
b. nitrogen
c. methane
d. water vapour

65. Which of the following gives the main reason that the sky looks blue?

a. the scattering of sunlight by air molecules
b. the emission of blue light by the atmosphere
c. the absorption of blue light by the air
d. the presence of water vapour

66. Referring to the figure below, in which direction is energy being transported?

a. upward at first, and then downward
b. downward
c. upward
d. downward at first, and then upward

67. At which of the following wavelengths does the Earth emit radiation of greatest intensity?

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a. visible wavelengths
b. ultraviolet wavelengths
c. radio wavelengths
d. infrared wavelengths

68. If the Earth's average surface temperature were to increase, what would happen to the amount of radiation emitted from the Earth's surface?
a. It would decrease.
b. It would remain stable.
c. It would increase.
d. It would decrease for a time, and then increase.

69. Which of the following statements explains why the albedo of the moon is 7 percent?
a. 7 percent of the sunlight striking the moon is absorbed.
b. 7 percent of the sunlight striking the moon is reflected.
c. Only 7 percent of the sun's energy absorbed by the moon is emitted back to space.
d. 93 percent of the sunlight striking the moon is reflected.

70. Which of the following has a wavelength shorter than that of violet light?
a. red light
b. green light
c. blue light
d. ultraviolet radiation

71. On a sunny day in winter when there is a large snowpack on the ground you notice it appears brighter outside than on a sunny day when there is no snow on the ground. What best explains this scenario?
a. Snow has a higher albedo than bare ground and reflects more solar radiation.
b. The sun emits more solar radiation in the winter months.
c. Snow emits more infrared radiation than bare ground.
d. The sun emits more ultraviolet radiation in the winter months.

72. Which of the following statements describes the radiative behaviour of a red shirt?
a. It selectively absorbs infrared wavelengths and scatters the rest.
b. It selectively scatters red wavelengths of visible light and absorbs the rest.
c. It selectively absorbs red wavelengths and scatters infrared wavelengths.
d. It selectively absorbs red wavelengths of visible light and scatters the rest.

73. Which of the following options gives the proper order for the types of radiation, from shortest to longest wavelength?
a. infrared, visible, ultraviolet
b. visible, infrared, ultraviolet
c. visible, ultraviolet, infrared
d. ultraviolet, visible, infrared

74. Which of the following is the range of wavelengths corresponding to the maximum amount of radiation emitted by the

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sun?

a. 0.5 micrometre
b. 1 micrometre
c. 10 micrometres
d. 30 micrometres

75. Which of the following processes explains why our skin feels colder immediately after stepping out of a hot tub?
a. latent heat of condensation
b. latent heat of fusion
c. latent heat of evaporation
d. latent heat of sublimation

76. Which of the following process is occurring when water droplets form on the outer surface of a glass of water?
a. latent heat of fusion
b. latent heat of evaporation
c. latent heat of fission
d. latent heat of condensation

77. Which of the following statements describes the roof of a home where snow melts readily?
a. It is a poor conductor of heat.
b. It is a good radiator of heat.
c. It is a poor radiator of heat.
d. It is a good conductor of heat.

78. Which of the following statements best describes why holes develop in snow around tree trunks?
a. Snow is a poor absorber of visible light.
b. Snow is a poor reflector of visible light.
c. Snow is a good absorber of infrared energy.
d. Snow is a good emitter of infrared energy.

79. Referring to the figure below, which of the following two energy transport processes are illustrated by the warm air rising?

a. advection and latent heat energy transport
b. convection and electromagnetic radiation
c. convection and latent heat energy transport
d. advection and electromagnetic radiation

80. Which of the following describes what always happens when air rises?

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a. It contracts and cools.
b. It contracts and warms.
c. It expands and warms.
d. It expands and cools.

81. Which of the following gases is NOT considered one that is responsible for enhancing the Earth's greenhouse effect?
a. chlorofluorocarbons
b. carbon dioxide
c. molecular oxygen
d. nitrous oxide

82. Although the polar regions radiate away more heat energy than they receive by insulation in the course of a year, what prevents them from becoming progressively colder each year?
a. circulation of heat by the atmosphere and oceans
b. release of latent heat to the atmosphere when polar ice melts
c. conduction of heat through the interior of the Earth
d. concentration of Earth's magnetic field lines at the poles

83. Which of the following describes how a plate of hot food cools when it is left on the table for a while?
a. by advection
b. by specific heat
c. by latent heat energy release
d. by radiation

84. As air in the figure above moves from A to B, what will happen to its density?
a. It will increase.
b. It will decrease.
c. It will decrease at first, and then increase.
d. It will remain the same.

85. Which of the following processes occurs when sinking air warms?
a. expansion
b. compression
c. friction
d. condensation

86. Which of the following is released as sensible heat during the formation of clouds?
a. shortwave radiation
b. longwave radiation
c. latent heat
d. potential energy

87. Which of the following descriptions applies to sunspots?
a. They are warmer regions on the sun's surface.

b. They are located in regions of strong magnetic fields.
c. They reach a maximum size approximately every 15 years.
d. They appear lighter than the rest of the sun's surface.

88. Which of the following describes the temperature of a rising air parcel?
a. It warms due to compression
b. It cools due to compression
c. It warms due to expansion
d. It cools due to expansion

89. Which of the following describes what the average Earth surface temperature would be without the atmospheric greenhouse effect?
a. higher than it is now
b. the same as it is now
c. much more variable than it is now
d. lower than at it is now

90. In defining heat, which of the following describes the direction of energy transfer?
a. from high pressure areas to low pressure areas
b. from cold objects to hot objects
c. from low pressure areas to high pressure areas
d. from hot objects to cold objects

91. According to Wien's displacement law, which of the following expressions describes the wavelength at which maximum radiation occurs?
a. The wavelength is inversely proportional to the temperature.
b. The wavelength is proportional to the pressure.
c. The wavelength is proportional to the temperature.
d. The wavelength is inversely proportional to the pressure.

92. Which of the following terms refers to the horizontal transport of any atmospheric property by the wind?
a. radiation
b. advection
c. redistribution
d. conduction

93. Which of the following describes how the atmospheric greenhouse effect is mainly produced?
a. Gases in the atmosphere absorb and re-emit ultraviolet radiation.
b. Clouds absorb and re-emit visible light.
c. Gases in the atmosphere absorb and re-emit infrared radiation.
d. Gases in the atmosphere absorb and re-emit visible light.

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94. Imagine that the temperature of the sun changed. Describe or discuss some of the effects that this might have on the Earth's energy budget and the Earth's climate.

95. If frost was predicted in a region of citrus crops why would it be advisable to sprinkle the crops with water before the expected frost?

96. Does a rising parcel of air always expand? Why? Does this expansion cause the air temperature to increase or decrease? Why?

97. Considering the Earth's annual energy balance, the Earth absorbs approximately 51 units of solar energy but emits 117 units of infrared energy. What prevents the Earth from getting colder and colder?

98. On a hot summer day what is the best type and colour of clothing to wear in order to keep cool? Justify your answer.

99. Describe and give examples of different ways that heat can be transported in the atmosphere.

100. In what ways is the atmospheric greenhouse different from an agricultural greenhouse?

101. On a sunny day in winter, why does it appear to be much brighter outside on a day when there is a snowpack on the ground as opposed to a sunny winter day with no snowpack?

102. Explain how energy in the form of sunlight absorbed at ground level can 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?

103. 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?

104. Several planets in our solar system are farther from the sun and cooler than the Earth. Do they emit electromagnetic radiation? Why are planets visible in the sky at night?

105. How does increased cloud cover cause an increase in the Earth's average surface temperature? How does increased cloudiness cause a decrease in average surface temperatures?

106. Explain how the specific heat of water can cause the climate of a coastal location to be much different than an inland location.

107. Many automobile engines are cooled by water that 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?

108. What are the other factors, besides increasing CO_2 concentrations, which affect global warming?

109. Many people will blow on a bowl of hot soup to try to cool it. In your view, what are the two most important processes of heat transport being used to cool the soup?

110. When you remove a cold beverage from a refrigerator in a humid room, water vapour condenses on the sides of the container. Does this condensation act to warm or cool the beverage, or does it have no effect on the beverage's temperature?

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Answer Key

1. b
2. a
3. a
4. c
5. b
6. d
7. a
8. a
9. b
10. d
11. b
12. b
13. c
14. a
15. d
16. b
17. d
18. d
19. b
20. c
21. a
22. b
23. a
24. d

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25. d

26. c

27. d

28. b

29. b

30. c

31. a

32. a

33. a

34. b

35. b

36. b

37. c

38. b

39. a

40. a

41. b

42. d

43. c

44. a

45. c

46. a

47. a

48. a

49. d

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50. c

51. a

52. a

53. d

54. c

55. d

56. b

57. a

58. c

59. d

60. a

61. c

62. d

63. d

64. d

65. a

66. c

67. d

68. c

69. b

70. d

71. a

72. b

73. d

74. a

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75. c

76. d

77. d

78. c

79. c

80. d

81. c

82. a

83. d

84. b

85. b

86. c

87. b

88. d

89. d

90. d

91. a

92. b

93. c

94. Answers may vary.

95. Answers may vary.

96. Answers may vary.

97. Answers may vary.

98. Answers may vary.

99. Answers may vary.

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100. Answers may vary.

101. Answers may vary.

102. Answers may vary.

103. Answers may vary.

104. Answers may vary.

105. Answers may vary.

106. Answers may vary.

107. Answers may vary.

108. Answers may vary.

109. Answers may vary.

110. Answers may vary.