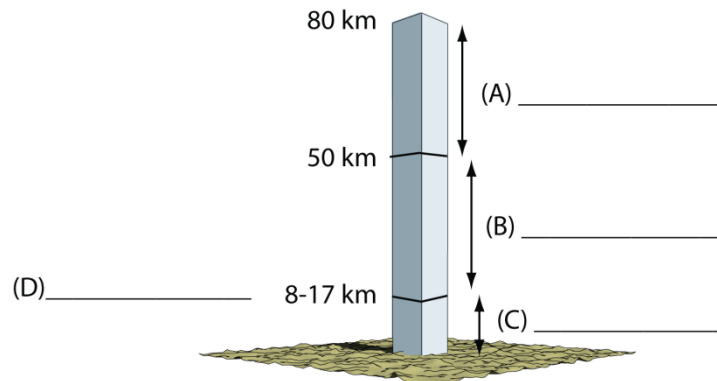


## Chapter 9 – Cyclones

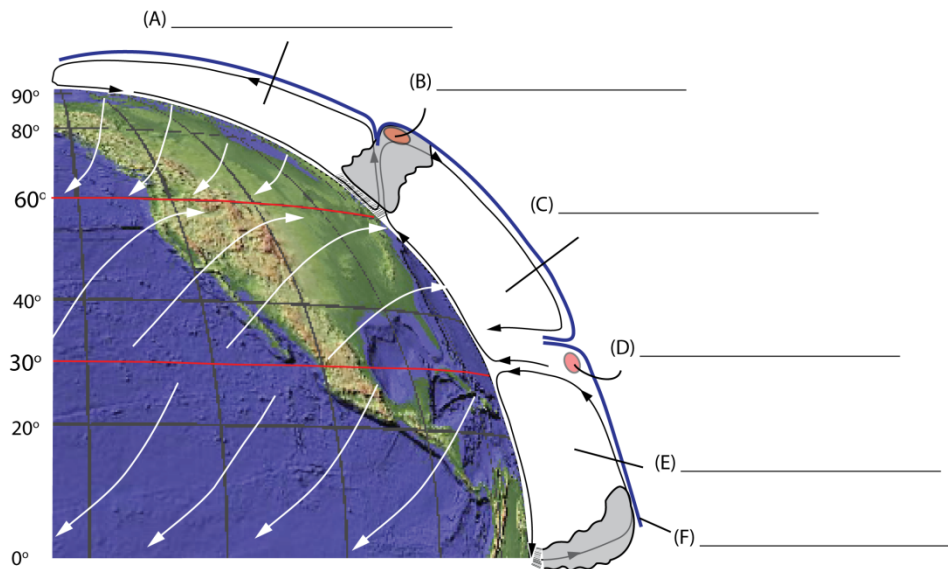
### Practice Exam and Study Guide

1. The Earth's atmosphere extends from sea level to about \_\_\_\_\_ kilometers.
2. Select from the following list the two elements that make up most (i.e., ~99%) of the Earth's atmosphere
  - a. N
  - b. O
  - c. Ar
  - d. CO<sub>2</sub>
  - e. H<sub>2</sub>O
3. \_\_\_\_\_ percent of the mass of the Earth's atmosphere lies within its lower 80 kilometers.
4. In the following illustration, please fill in the missing labels for the Earth's atmosphere.



5. In what layer of the atmosphere does the weather of planet Earth occur?
6. In what layer of the Earth's atmosphere are greenhouse gases stored?
7. What is the tropopause?
8. What heat transfer process drives the poleward movement of hot tropical air masses?

9. In the following illustration, please fill in the missing labels for the key atmospheric features of planet Earth.



10. What is another name for 30° North or South latitude?
11. What force causes wind currents to bend to the right of their direction of motion in the Northern Hemisphere and to their left in the Southern hemisphere?
12. What force causes air to flow from high to low pressure regions?
13. Where is the Intertropical Convergence Zone located?
14. What is the name of the surface winds that blow from NE to SW between 0° and 30° North or South latitude?
15. What cell do the Intertropical Convergence Zone, Horse Latitudes, and the Trade Winds play an important role in?
16. How would you describe air masses at the poles?
17. As cold dry air masses at the poles move south and north in the northern and southern hemispheres respectively they encounter warm moist air flowing in the opposite direction at about what latitudes?

18. Where did the warm moist air referred to in question 17 originate from?
19. What happens at 60° N and S latitude?
20. What cell do the Polar Easterlies and 60° N and S latitude play an important role in?
21. What is the name of the cell lying between the Hadley and polar cells?
22. What are the winds that commonly occur between 30° and 60° N or S latitude called?
23. What are Jet Streams and where do they occur?
24. For a stream of air to be classified as a jet stream it can't be moving slower than
- 54 km/hour
  - 64 km/hour
  - 90 km/hour
  - 94 km/hour
  - None of the above
25. Select from the following list the typical dimensions of a jet stream.
- 100 to several 1000 kilometers long
  - 10 to several 100 meters long
  - 160 to 500 kilometers wide
  - 160 to 500 meters in wide
  - 1 kilometer deep
  - 5 kilometers deep
26. When two air masses with significantly different temperature and density meet, the resulting difference in pressure between the two is the greatest at the \_\_\_\_\_ elevation. This pressure difference causes air to flow from the \_\_\_\_\_ toward the \_\_\_\_\_ air mass. In the Northern Hemisphere, the \_\_\_\_\_ causes the warmer flowing air mass to be strongly deflected to the right parallel to the interface between the two contrasting air masses. The strongly deflected air mass flowing parallel to the boundary between the two contrasting air masses is a jet stream if its speed is in excess of \_\_\_\_\_.

27. The Polar Jet lies at an elevation of

- a. ~3 to 4 kilometers
- b. ~5 to 6 kilometers
- c. ~7 to 12 kilometers
- d. ~15 – 17 kilometers
- e. None of the above

28. The Subtropical Jet lies at an elevation of

- a. ~5 to 10 kilometers
- b. ~10 to 16 kilometers
- c. ~16 to 20 kilometers
- d. ~20 -22 kilometers
- e. None of the above

29. What are jet streaks?

30. What are the three stages that thunderstorms pass through?

31. What stage in the development of a thunderstorm is latent heat important?

32. What stage of development of a thunderstorm is indicated by the cloud in the following photograph?



33. What is the cloud shown in question number 32 called?

34. In what stage of thunderstorm development are both lightening and high winds present?

35. At what stage of development do thunderstorms rise until they reach the warmer air of the tropopause?
36. When downdrafts push down out of a cloud and spread outward cutting off the inflow to a thunderstorm, then the stage of development is referred to as the \_\_\_\_\_ stage.
37. Technically, what is a cyclone?
38. As viewed from the North Pole, in what direction does the Earth rotate?
39. Tropical cyclones are sometime referred to as \_\_\_\_\_-core storm systems.
40. Tropical cyclones form almost exclusively in the \_\_\_\_\_ regions around the globe.
41. A tropical cyclone in the Atlantic and eastern Pacific is referred to as a
- hurricane
  - typhoon
  - cyclone
42. A tropical cyclone western Pacific and Philippines is referred to as
- hurricane
  - typhoon
  - cyclone
43. Tropical cyclones typically begin as a complex of thunderstorms but then evolve through a series of stages. The first stage after a complex of thunderstorms form is the formation of a weak
- Tropical storm
  - Tropical depression
  - Tropical typhoon
  - Tropical trough
  - None of the above

44. If wind speeds in the tropical depression reach 63 km/hour (39 mph), then it is classified as a
- Tropical storm
  - Hurricane
  - Typhoon
  - Tropical trough
  - None of the above
45. If wind speeds in a tropical storm reach 117 km/hour (73 mph), then depending upon its location it is classified as a
- Hurricane
  - Cyclone
  - Typhoon
46. Given that all other factors are favorable, is it likely that a tropical cyclone will form if the water temperature is less than 26.5°C (80°F)? If not, then why not?
47. Given that all other factors are favorable, is it likely that a tropical cyclone will form if the relative humidity is low in the lower and middle troposphere? If not, then why not?
48. Given that all other factors are favorable, is it likely that a tropical cyclone will form if high amounts of wind shear are present? If not, then why not?
49. Given that all other factors are favorable, is it likely that a tropical cyclone will form if a tropical storm forms within 555 kilometers of the equator? If not, then why not?
50. A calm and cloudless circular region in the center of the cyclone is called the \_\_\_\_\_.
51. The eye can be anywhere from \_\_\_\_\_ to \_\_\_\_\_ kilometers in diameter.
52. A circular area surrounding the eye and containing strong thunderstorms is called the \_\_\_\_\_.
53. Are pressures in the eye of a tropical cyclone higher or lower than those outside the eye of the storm?
54. What might be the difference in sea level between the eye and some point outside the storm?
55. Where do the greatest wind speeds and heaviest precipitation in a cyclone occur?

56. Radiating outward from the eyewall of a cyclone are bands of clouds that make up the \_\_\_\_\_.

57. A Category 1 hurricane has sustained wind speeds of

- a. ~119 - 153 km/hour (74-95 mph)
- b. ~154.5 - 177 km/hour (96-110 mph)
- c. ~178.6 – 209 km/hour (111-130 mph)
- d. ~210.8 – 249 km/hour (131-155 mph)
- e. Greater than or equal to ~249 km/hour (155 mph)

58. A Category 2 hurricane has sustained wind speeds of

- a. ~119 - 153 km/hour (74-95 mph)
- b. ~210.8 – 249 km/hour (131-155 mph)
- c. ~154.5 - 177 km/hour (96-110 mph)
- d. ~178.6 – 209 km/hour (111-130 mph)
- e. Greater than or equal to ~249 km/hour (155 mph)

59. A Category 3 hurricane has sustained wind speeds of

- a. ~154.5 - 177 km/hour (96-110 mph)
- b. ~210.8 – 249 km/hour (131-155 mph)
- c. ~178.6 – 209 km/hour (111-130 mph)
- d. ~119 - 153 km/hour (74-95 mph)
- e. Greater than or equal to ~249 km/hour (155 mph)

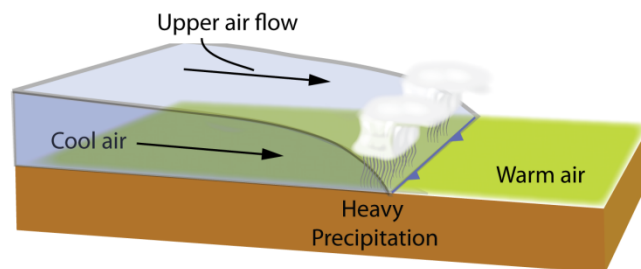
60. A Category 4 hurricane has sustained wind speeds of

- a. Greater than or equal to ~249 km/hour (155 mph)
- b. ~119 - 153 km/hour (74-95 mph)
- c. ~178.6 – 209 km/hour (111-130 mph)
- d. ~154.5 - 177 km/hour (96-110 mph)
- e. ~210.8 – 249 km/hour (131-155 mph)

61. A Category 5 hurricane has sustained wind speeds of

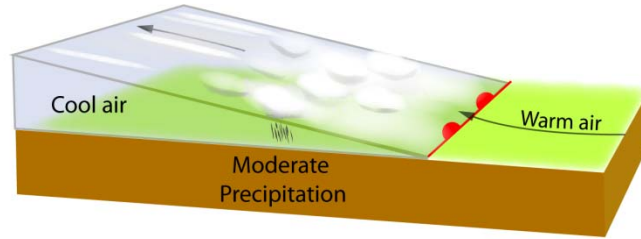
- a. ~119 - 153 km/hour (74-95 mph)
- b. ~154.5-177 km/hour (96-110 mph)
- c. ~178.6 – 209 km/hour (111-130 mph)
- d. ~210.8 – 249 km/hour (131-155 mph)
- e. Greater than or equal to ~249 km/hour (155 mph)

62. Which of the following hurricanes were classified as a category 5?
- Camille
  - Katrina
  - Andrew
  - Liz
  - None of the above
63. A mid-latitude cyclone is an area of low pressure lying between \_\_\_\_\_ degrees and \_\_\_\_\_ degrees north or south latitude.
64. A mid-latitude cyclone can reach \_\_\_\_\_ kilometers (~1243 miles) in diameter.
65. Mid-latitude cyclones are commonly the result of cold dry air masses of the \_\_\_\_\_ cell flowing toward the equator interacting with warm and moist poleward flowing air masses of the \_\_\_\_\_ cell.
66. A warm front forms when the
- leading edge of poleward flowing warm moist air meets and replaces a mass of cold dry air.
  - leading edge of cold dry air meets and replaces a mass of warm moist air.
67. A cold front forms when the
- leading edge of poleward flowing warm moist air meets and replaces a mass of cold dry air.
  - leading edge of cold dry air meets and replaces a mass of warm moist air.
68. What kind of front is illustrated below?



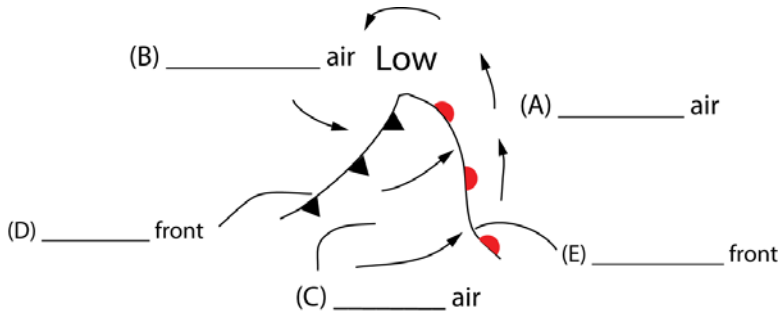


69. What kind of front is illustrated below?

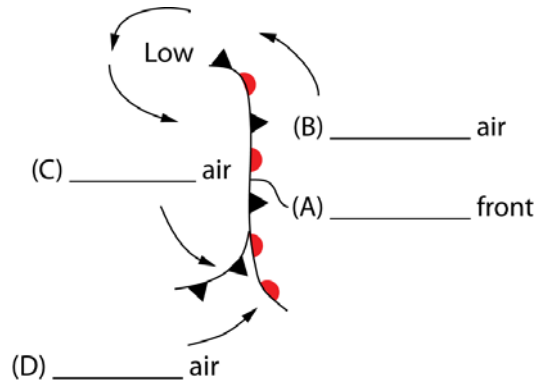


70. When a cold and warm front merge the front is called \_\_\_\_\_.

71. Given the following weather map of the beginning stage of a mid-latitude cyclone, please fill in the missing labels.



72. Given the following weather map of the terminal stage, please fill in the missing labels.



73. In a mid-latitude cyclone where would you expect to find a line of thunderstorms: over a cold or warm front?

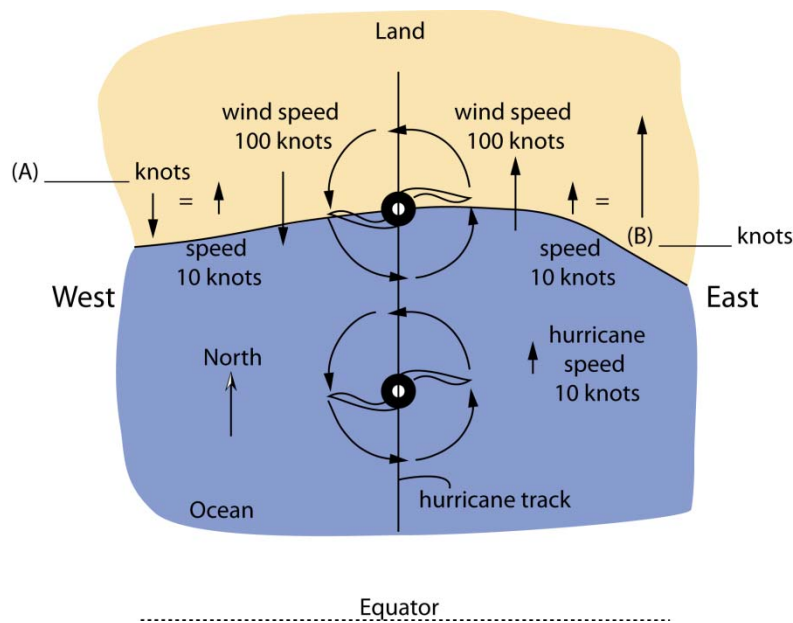
74. Which commonly mover faster, warm- or cold-fronts?

75. Over the United States mid-latitude cyclones move from \_\_\_\_\_ to \_\_\_\_\_.

76. Select from the following list, models used to explain the development of mid-latitude cyclones.

- a. Milankovitch
- b. Mohorovičić
- c. Norwegian
- d. Shapiro-Keyser
- e. Werner

77. Consider the hypothetical cyclone in the following illustration. Given the provided wind and hurricane speeds, please fill in the blanks ((A) and (B)) for the wind speed on the eastern and western sides.



78. What is storm surge?

79. If a hurricane comes ashore along an E-W trending coastal area with a northward direction of travel, what side of the hurricane, east or west, is in greatest danger of coastal flooding? Why?

80. What are squall lines and where might you expect them to form?

81. On a global basis where are the greatest number of tornadoes spawned?

82. Select from the following list the most destructive, in terms of physical damage, tropical cyclone in the history of the United States.
- Andrew
  - Rita
  - Camille
  - Galveston hurricane of 1900
  - Great Storm of 1987
83. Select from the following list the most deadly hurricane in the history of the United States.
- Andrew
  - Rita
  - Camille
  - Galveston hurricane of 1900
  - Great Storm of 1987
84. Select from the following list the extratropical cyclone with the highest wind speeds ever recorded.
- Andrew
  - Rita
  - Camille
  - Galveston hurricane of 1900
  - Great Storm of 1987
85. Select from the following list the hurricane with the highest sustained winds to come ashore in the history of the United States.
- Andrew
  - Rita
  - Camille
  - Galveston hurricane of 1900
  - Great Storm of 1987
86. Where did the Great Storm of 1987 occur?
- South Carolina
  - Florida
  - Louisiana
  - United Kingdom
  - Cuba

87. How many trees were destroyed during the Great Storm of 1987?
- 5,000
  - 15,000
  - 150,000
  - 1,500,000
  - 15,000,000
88. How many lives were lost during the Great Storm of 1987?
- 5
  - 10
  - 15
  - 19
  - 20
89. How many people lost their lives during the Galveston Hurricane of 1900?
- 100 – 1,000
  - 1,000 – 3,000
  - 6,000 – 12,000
  - 13,000 – 15,000
  - 2,000 – 3,000
90. Select from the following list the estimated costs associated with damage from Hurricane Andrew
- \$250,000
  - \$2,500,000
  - \$25,000,000,000
  - \$250,000,000
91. Sustained winds associated with Hurricane Camille are estimated to have been
- 190 mph (305 km/hour)
  - 100 mph (~161 km/hour)
  - 75 mph (~121 km/hour)
  - 300 mph (~483 km/hour)
  - None of the above

## Answers

- 10,000
- a. N, b. O
- 97

4. (A) Mesosphere, (B) Stratosphere, (C) Troposphere, (D) Tropopause
5. Troposphere
6. Stratosphere
7. The tropopause is the boundary separating the troposphere and stratosphere
8. Convection
9. (A) Polar cell, (B) Polar jet stream, (C) Ferrel cell, (D), Subtropical jet stream, (E) Hadley cell, (F) tropopause
10. Horse latitudes
11. The Coriolis force
12. Pressure-gradient force
13. Along and parallel to the equator
14. Trade winds
15. Hadley cell
16. They are cold and dry
17. 60° N or S
18. The equator
19. Warm moist air lofted toward the tropopause, undergoes condensation and precipitation occurs
20. The Polar cell
21. Ferrel cell
22. Prevailing Westerlies
23. Jet streams are narrow fast flowing air currents occurring near the tropopause
24. d. 94 km/hour
25. a. 100 to several 1000 km long, c. 160 to 150 km wide, e. 1 km deep
26. highest, warmer , colder, Coriolis force, 94 km/hour
27. c. ~7 to 12 kilometers
28. b. ~10 to 16 kilometers
29. Jet streaks are the fastest flowing parts of jet streams
30. Cumulous towers, mature, dissipation
31. Cumulous stage
32. mature
33. cumulonimbus
34. mature
35. mature
36. dissipation
37. A cyclone is an area of closed, circular atmospheric motion rotating in the same direction as the Earth.
38. Counterclockwise
39. Warm
40. Tropical
41. a. hurricane

42. b. typhoon
43. b. tropical depression
44. a. tropical storm
45. a. through c. are all correct
46. No, the water temperature needs to be above 80°F. Under this condition the overlying atmosphere will be unstable enough to sustain convection and thunderstorm development.
47. No, the humidity needs to be high so that there will be a lack of evaporation of moisture from clouds, and thus the clouds can carry more water vapor as they rise.
48. No, the wind shear needs to be low so that the latent heat produced during the production of rain is localized rather than spread out.
49. No, the Coriolis force is too weak to non-existent within this distance from the equator, and as a result the required rotation will not develop.
50. Eye
51. 20, 50
52. Eyewall
53. Lower
54. The difference in sea level between the eye of a tropical storm and areas outside the eye can be as much as 0.5 meters (~1.64 feet).
55. Within the eyewall
56. Spiral rain bands
57. a. ~119-153 km/hour
58. c. ~154.5-177 km/hour
59. c. ~178.6-209 km/hour
60. e. ~210.8-249 km/hour
61. e. greater than or equal to ~249 km/hour
62. a. Camille, b. Katrina
63. 30, 60
64. 2,000
65. Polar, Ferrel
66. a. leading edge of poleward flowing warm moist air meets and replaces a mass of cold dry air.
67. b. leading edge of cold dry air meets and replaces a mass of warm moist air.
68. Cold front
69. Warm front
70. Occluded
71. (A) cool, (B) cold, (C) warm, (D) cold, (E) warm
72. (A) occluded, (B) cool, (C) cold, (D) warm
73. Over the cold front
74. Cold fronts commonly overtake warm fronts
75. West, east
76. c. Norwegian, d. Shapiro-Keyser

77. (A)  $100 - 10 = 90$  knots, (B)  $100 + 10 = 110$  knots
78. Storm surge is the rise of sea level brought on by low-pressure high winds, and large waves as cyclones come ashore.
79. East side – this side will have the highest sustained winds
80. Bands of thunderstorms – along and parallel to cold fronts
81. Great Plains region of United States
82. a. Andrew
83. d. Galveston hurricane of 1900
84. Great Storm of 1987
85. c. Camille
86. d. United Kingdom
87. e. 15,000,000
88. d. 19
89. c. 6,000-12,000
90. c. \$25,000,000,000
91. a. 190 mph (305km/hour)