

Energy Transfer in the Atmosphere

Textbook pages 436–459

Before You Read

What do you think causes wind? Write your thoughts in the lines below.



Mark the Text

In Your Own Words

Highlight the main idea in each paragraph. Stop after each paragraph and put what you have read into your own words.



Reading Check

Name the five layers of the atmosphere.

What is Earth's atmosphere like?

Many planets have **atmospheres**, layers of gases that extend above a planet's surface. Earth's atmosphere is made up of five layers: from lowest to highest, they are the troposphere, stratosphere, mesosphere, thermosphere, and exosphere.

These layers differ in chemical composition, average temperature, and density. ✓

The troposphere is the layer nearest the surface of the Earth. Almost all water vapour and dust in the atmosphere is found here. The average temperature near Earth is 15°C but at the top of the troposphere is -55°C. 99% of the gases in the troposphere are nitrogen and oxygen.

The stratosphere has dry air and an average temperature of about -55 °C at the bottom and 0 °C at the top. The ozone layer, which absorbs much of the ultraviolet radiation from the Sun, is in the stratosphere.

Temperatures in the mesosphere can reach as low as -100 °C. Every day, small pieces of dust and meteors rush through the mesosphere.

Temperatures in the thermosphere can reach 1500 °C to 3000 °C. The northern lights, or aurora borealis, are a result of charged particles colliding in the thermosphere.

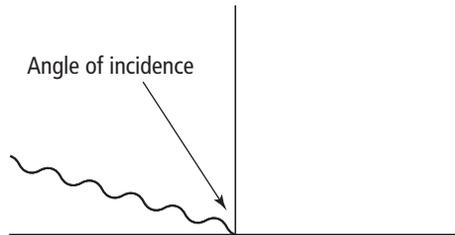
The boundaries of the exosphere are not well defined, and this layer merges with outer space.

The atmosphere is constantly changing, due to many factors, including the Sun's rotation and the effects of day and night.

How is the atmosphere warmed?

Solar radiation transfers heat to Earth. The amount of solar radiation that reaches a certain area is called **insolation**.

Higher latitudes receive less insolation due to a greater **angle of incidence**. The angle of incidence is the angle that occurs between a ray reaching a surface and a line perpendicular to that surface. It increases with latitude.



Very little solar radiation heats the atmosphere directly. Solar radiation arrives in short wavelengths, some of which pass through the atmosphere to Earth's surface, where they are absorbed. Earth's surface reradiates some of this energy as longer, infrared waves. The atmosphere absorbs this infrared radiation and convection transfers the thermal energy throughout the atmosphere.

Earth has a **radiation budget** that keeps incoming and outgoing energy in balance. Incoming short-wave solar radiation is reflected and absorbed to various degrees. **Albedo** describes the amount of radiation reflected by a surface. Forested regions and other dark areas (low albedo), for example, will absorb more radiation than areas covered in ice and snow (high albedo).

What is atmospheric pressure?

Atmospheric pressure is the pressure exerted by the mass of air above any point on Earth's surface. Atmospheric pressure is measured with a **barometer** in **Kilopascals (kPa)**. As the atmospheric pressure changes, a capsule of flexible metal in an aneroid barometer expands or contracts. Kilopascals measure the force per one square metre. Changes in atmospheric pressure occur as a result of the following:

1. **Altitude:** As altitude increases, atmospheric pressure decreases.
2. **Temperature:** Warm air is less dense than cold air, resulting in lower atmospheric pressure.
3. **Humidity:** **Humidity** is a measurement that describes the amount of water vapour in air. The greater the humidity, the lower the atmospheric pressure.

continued

High pressure system	Low pressure system
air cools and becomes more dense	air warms and becomes less dense
air mass contracts, draws in surrounding air, and sinks	air mass expands and rises
due to weight of extra air, atmospheric pressure increases; high pressure air moves outward toward areas of low pressure, creating wind	air pressure at Earth's surface decreases and draws in air from areas of high pressure, creating wind
wind flows clockwise in the northern hemisphere	wind flows counterclockwise in the northern hemisphere
air becomes warmer and drier as it sinks, bringing clear skies	water vapour condenses as air cools, bringing wet weather

: What is an air mass?

: An **air mass** is a parcel of air with similar temperature and humidity throughout. Conditions in an air mass become like Earth's surface below it. When an air mass cools over a cold region, a high pressure system forms. Air masses that travel over warm regions may develop into low pressure systems. The boundary between two air masses is called a **front**. An approaching front means a change in the weather. The extent of the change depends on the amount of difference between conditions in the two air masses.



Reading Check

What is weather?

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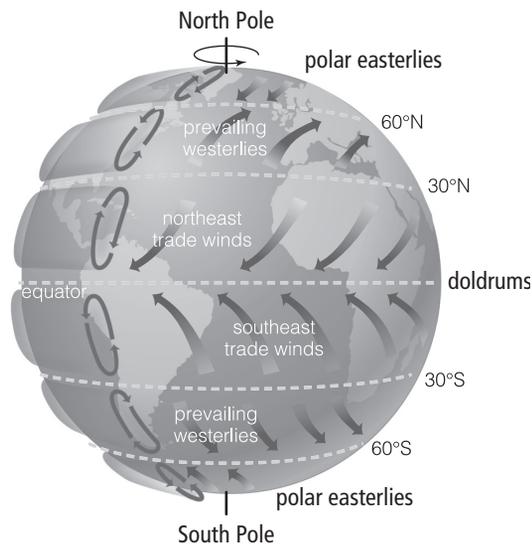
: **Weather** is the condition of the atmosphere in a specific place and at a specific time. Weather describes all aspects of the atmosphere, including temperature, atmospheric pressure, humidity, and wind speed and direction. Weather is closely connected to heat transfer in the atmosphere. As heat is transferred, convection moves air and thermal energy throughout the troposphere, causing various kinds of weather.

: Several types of extreme weather occur on Earth, including thunderstorms, tornados, and tropical cyclones.

: A tornado is a violent funnel-shaped column of air. It is found when high altitude winds meet large thunderstorms. Surface winds caused by tornadoes can reach 400 km/h. Tropical cyclones, or hurricanes, result from the exchange of thermal energy in the tropics. Warm moist air is lifted high into the atmosphere. As rain is produced, thermal energy is released. Warm air rushes to replace the rising air, and the Coriolis effect forces the air to rotate. The result is a massive, spinning storm. ✓

How is wind generated on Earth?

Wind is the movement of air from an area of higher pressure to an area of lower pressure. Geographic features such as mountains, oceans, and lakes greatly affect the characteristics of **local winds**. **Prevailing winds** are winds that are typical for a certain region. Over long distances, wind is also affected by Earth's rotation. The **Coriolis effect** is a change in the direction of moving air, water, or objects due to Earth's rotation. The Coriolis effect and convection currents (rising warm air and sinking cool air) result in three major global wind systems: the trade winds, the prevailing westerlies, and the polar easterlies.



Jet streams form in the upper troposphere due to convection currents and become bands of fast-moving air in the stratosphere. They are so strong that airline pilots try to fly with them.

Use with textbook pages 436–440.

The Earth's atmosphere

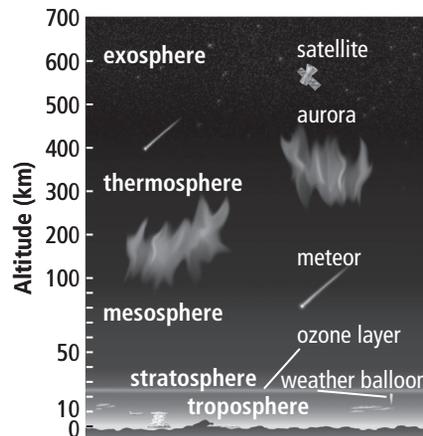
Answer the questions below.

1. What is “air”?

2. What two gases make up 99 percent of dry air?

3. What factors cause the atmosphere to constantly change?

4. The Earth's atmosphere is made up of five layers. Each layer differs in average altitude, chemical composition, average temperature, and density.



Complete the table below summarizing the characteristics of each layer of the Earth's atmosphere.

Layer	Altitude above sea level	Average temperature	Factors affecting composition
troposphere			
stratosphere			
mesosphere			
thermosphere			
exosphere			

Use with textbook pages 443–448.

What is weather?

1. Define the term weather.

2. What moves air and thermal energy throughout the troposphere?

3. Explain how an aneroid barometer works.

4. What is the SI unit for atmospheric pressure? What does it represent?

5. What causes the sensation of your ears “popping” when you are flying in an airplane?

6. Explain how the following factors affect atmospheric pressure.

(a) temperature increases

(b) warm air mass pushes into region of cold air

(c) cold air mass pushes into a region of warm air

7. Compare the terms wind and air mass.

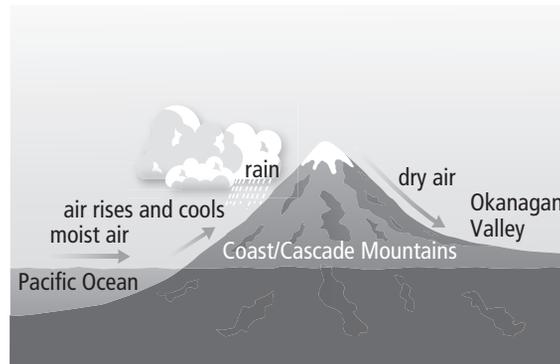
8. What weather pattern occurs when a high pressure system forms?

9. What weather pattern occurs when a low pressure system forms?

Use with textbook pages 448–454.

Weather patterns

Prevailing Winds of British Columbia

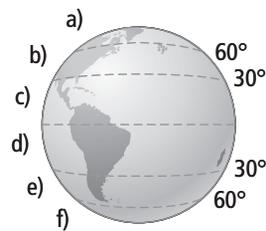


1. Observe the above figure, which depicts the prevailing winds on the west coast. With prevailing winds occurring,

(a) what would the weather pattern be in Vancouver, British Columbia?

(b) what would the weather pattern be in Calgary, Alberta?

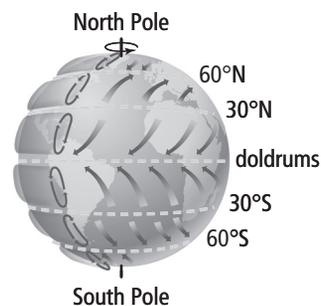
2. Using the diagram, illustrate the Coriolis effect by adding arrows to depict the directions that winds travel in the northern hemisphere and southern hemisphere.



Wind Patterns Due to Coriolis Effect

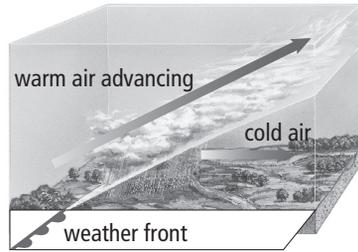
3. Use the vocabulary terms that follow to label Earth's global wind systems on the diagram below. Some terms may be used more than once.

- ◆ northeast trade winds
- ◆ polar easterlies
- ◆ southeast trade winds
- ◆ prevailing westerlies

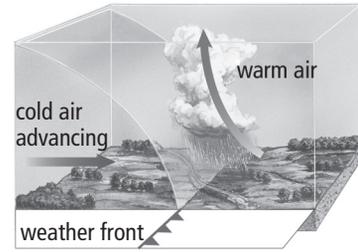


4. What types of weather will occur in the figures below?

(a)



(b)



5. Draw a series of diagrams to illustrate the developmental stages of a tornado.

<p>(a) funnel cloud develops</p>	<p>(b) funnel cloud becomes vertical and touches the ground</p>	<p>(c) tornado moves along ground</p>
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6. Describe what causes a hurricane to develop.

Energy transfer in the atmosphere

Match each Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Terms	Descriptor
1. _____ atmospheres	A. local winds caused by the different rates at which land and water transfer thermal energy
2. _____ Coriolis effect	B. tropical cyclones
3. _____ hurricanes	C. layers of gases that extend beyond a planet's surface
4. _____ kilopascals (kPa)	D. a change in the direction of moving air, water, or objects due to Earth's rotation
5. _____ ozone layer	E. violent, funnel-shaped column of rotating air that touches the ground
6. _____ prevailing winds	F. winds that are typical for a certain region
7. _____ sea breezes	G. the SI unit that measures the vertical force of atmospheric pressure per unit area
8. _____ tornado	H. the atmospheric layer that absorbs much of the ultraviolet radiation from the Sun

Circle the letter of the best answer.

9. In which layer of the Earth's atmosphere is the ozone layer found?
- A.** exosphere
 - B.** mesosphere
 - C.** stratosphere
 - D.** troposphere

10. Where are jet streams found?
- A.** exosphere
 - B.** mesosphere
 - C.** stratosphere
 - D.** troposphere
11. What causes an offshore breeze to develop?
- A.** land mass has warmed up
 - B.** land mass has cooled down
 - C.** ocean mass has warmed up
 - D.** ocean mass has cooled down
12. A high pressure weather system would result in what type of weather developing over a geographic area?
- A.** rainy weather
 - B.** tornado
 - C.** clear skies
 - D.** windy conditions