Get Ready for Unit 3

Climate Change

Answers for page 94

Multiple Choice

1. d

2. b

3. d

4. a

5. b

6. a

7. b

8. c

Answers for page 95

Written Answer

9. Nitrogen oxides are compounds composed of differing proportions of nitrogen and oxygen. NO_2, for example, is a component of smog.

10. O_2 is a molecule, not a compound. A compound is made of two or more different elements. A molecule is the smallest discrete particle of a pure substance. Some molecules are compounds, but other molecules, like O_2, are made of two or more atoms of the same element and therefore are not compounds.

11. The biosphere is the area of Earth where there are living things. The biosphere exists within and among the other spheres. The atmosphere holds gases that organisms need to survive, such as carbon dioxide and oxygen. The hydrosphere, which includes both freshwater and saltwater habitats, is full of organisms. The hydrosphere also holds water the organisms need to survive. Many micro-organisms live in soil within Earth's lithosphere. Nutrients that living organism need are cycled through the lithosphere as well.

12. Carbon dioxide is a product of respiration and a reactant of photosynthesis. Carbon cycles from the atmosphere through the biosphere via these processes.

13. energy consumption, land use, and waste production

14. These substances form over millions of years from the remains of ancient plants. Humans have used large quantities of these fuels in the past few centuries. Because these are being used faster than they are being naturally formed, they are considered nonrenewable.

15. The structures are stomata. These are openings on the leaf surface through which gas exchange occurs. Through this opening, plants take up carbon dioxide from the atmosphere, which they use for photosynthesis.

16. A biodiversity hotspot is a place where there is an exceptionally large number of species in a relatively small area. Tropical regions contain many of the world's biodiversity hotspots. Carolinian Canada and the Leitrim Wetlands are biodiversity hotspots in Ontario.

Section 7.1 Review

Factors That Affect Climate Change

Answers for page 96

Multiple Choice

1. b

2. e

3. d

4. e

5. d

6. a

7. c

8. a

Answers for page 97

9. d

10. d

11. b

12. c

13. e

14. b

15. a

16. c

Answers for page 98

Written Answer

17. The field of snow has higher albedo. Albedo is an object's ability to reflect sunlight. Snow is light-coloured and reflects most of the sunlight that strikes it. In contrast, pavement is darker-coloured and absorbs more light energy.

18. Answers will vary slightly, depending on the area. Weather should include a description of wind, precipitation, and temperature. Students should either describe the weather at a particular time of the year, or describe different kinds of weather that may occur over the course of the year. Climate should include a description of the overall long-term weather patterns of the area.

19. There would not be seasons if Earth were not tilted on its axis. The average temperatures at different latitudes would not change throughout the year.

20. Not exactly true. Earth's orbit varies slightly over time. It is sometimes nearly circular, but, over a cycle of about 100 000 years, changes to a more elliptical orbit and back again.

21. Wobble affects the amount and intensity of the solar energy that is received by the northern and southern hemispheres. Due to Earth's wobble, one hemisphere may have greater temperature differences between seasons than the other.

22. The movement of tectonic plates changes the distribution of land and water. This affects the patterns of air and water circulation, which affects the transfer of thermal energy. Volcanoes also occur along the boundaries of tectonic plates. Eruptions can release particles that reflect solar radiation and have a cooling effect on global climate.

23. Winds cause ocean currents. Therefore, in both the northern and southern hemispheres, the currents will move in the same direction as the winds—clockwise in the northern hemisphere and counterclockwise in the southern hemisphere.

24. The Industrial Revolution refers to a period of time in the late 1700s in which there was rapid development, and subsequent use, of machines and transportation powered by fossil fuels. The burning of large quantities of fossil fuels released gases into the atmosphere, increasing the concentrations of certain gases. This continues today.

Answers for page 99

25. At point A, the rays are spread over the largest area. Each square metre of land therefore receives less solar energy than it would if the Sun's rays were more concentrated. The Sun's rays are most concentrated at point B. This explains why the equator is a much warmer climate than at the poles. The Sun's rays at point C are spread out, but not as much as they are at point A. The climate at point C is warmer than the climate at point A, but not as warm as is it at point B.

26. Earth would have much colder (about 34°C lower) average temperatures. Through the greenhouse effect, the atmosphere traps thermal energy, keeping Earth warmer than it would be otherwise.

27. a. Jet streams are high-altitude winds that travel long distances at high speeds. **b.** A jet stream can cause precipitation if it carries warm moist air or it can cause dry weather if it carries dry cool air.

28. Water has a high specific heat capacity, so a large quantity of energy is required to raise its temperature. Because of this, the same amount of heat energy has a greater effect on land masses than it does on water.

29. Warm air expands and rises, and cool air sinks. Air movement due to warming and cooling results in wind. In this way, wind transfers thermal energy from warm areas to cooler areas.

30. Yes, true. The Sun is the source of heat energy on Earth. This heat energy warms air, water, and land. It also produces wind, which causes surface ocean currents, and influences precipitation.

31. The IPCC is an international scientific panel that studies the causes and effects of climate change. The panel advises governments around the world about climate change and how it may impact people.

32. a. Solar variations, volcanic activity, moving continents, meteorites, and wobble have all contributed to climate changes in Earth's past. **b.** Current climate change is at least partly influenced by anthropogenic factors, including the burning of fossil fuels. **c.** Past climate changes have not included anthropogenic factors, while today's climate change does.

Section 7.2 Review

Describing Climates

Answers for page 100

Multiple Choice

1. c

2. c

3. b

4. d

5. e

6. e

7. a

8. c

Answers for page 101

9. d

10. d

11. b

12. c

13. b

14. e

15. d

16. d

Answers for page 102

Written Answer

17. The Trewartha system defines climate zones using the basic classification scheme of the Köppen climate system. It differs from the Köppen climate system because it includes additional distinctions between areas based on the types of vegetation in the regions.

18. A Köppen climate zone is defined by the abiotic factors of precipitation and temperature only, while a biome is defined by both abiotic factors and biotic factors, such as the type of plants and animals in an area.

19. An ecoregion is a subdivision of an ecozone. An ecozone is defined by both abiotic and biotic factors, and is separated from other ecozones by a particular geographic feature. An ecoregion is characterized by local landforms found within an ecozone.

20. a. A bioclimate profile is a graph of conditions including minimum/maximum/mean temperature, probability of frost, monthly total precipitation, number of days with rain/snow, and water surplus/deficit, that occur over a period of years. **b.** This system is helpful because it allows comparisons between different periods of time in the same location. This can reveal trends that could help to plan for future climate changes.

21. A temperate deciduous forest has a greater range of temperature throughout the year, colder than the temperate rainforest in the winter and warmer in the summer. A temperate deciduous forest would have precipitation consistently throughout the year while a temperate rainforest would have an extended rainy season and much greater total annual rainfall.

22. a. Boreal forest, desert, grassland, permanent ice, temperate deciduous forest, temperate rain forest, tropical rain forest, tundra. **b.** Tropical rain forest

23. a. Throughout the year, there is very little precipitation, with most occurring in May and June. **b.** Temperature changes greatly between seasons, peaking around 20°C in the summer months and getting below 0°C in the winter months. **c.** The extremely dry conditions suggest that this is the desert biome.

24. Near the Ganges River, climate change is expected to reduce precipitation. This will reduce crop yields and may force farmers to switch from wheat to a different crop. In Canada, warmer climate may cause areas that are now unsuitable for agriculture to become viable farmland, including for wheat production.

Answers for page 103

25. More people may be able to make a living as farmers. If the wheat is exported, it could become a valuable resource for Canada.

26. Both biomes and ecozones are defined by both climate features and biotic factors. Ecozones differ from biomes in that they also include geologic features and human features.

27. Climate factors, including patterns of precipitation and temperature, determine which plants can grow in an area.

28. a. Throughout the year, there is abundant precipitation, with most occurring in December through April. **b.** Temperature remains nearly consistent, just above 25°C. **c.** The consistent warm temperatures and rainy conditions suggest that this is the tropical rainforest biome.

29. The unequal warming of Earth's surface causes the different climate zones. Sunlight hits the equator directly, but is spread out over the polar regions.

30. A boreal forest has overall colder temperatures than a temperate deciduous forest. Boreal forests receive more precipitation in summer months, while temperate deciduous forests have precipitation spread evenly throughout the year, and more annual precipitation overall. Boreal forests are dominated by coniferous trees such as black and white spruce while deciduous forests are dominated by maple, birch, oak, and others.

31. a. The Köppen climate classification system has been modified by subdividing some categories, so that they are more specific. **b.** Scientists felt that the Köppen climate classification system had categories that were too broad.

32. Data gathered over many years will give better averages and better represent a region's climate, which is its long-term weather patterns.

Section 7.3 Review

Indicators and Effects of Climate Change

Answers for page 104

Multiple Choice

1. a

2. a

3. e

4. a

5. d

6. c

7. e

8. b

Answers for page 105

Written Answer

9. Global warming is a trend that reflects changes in average temperatures around the world. The average temperature for the entire world has increased, although particular places may have cooler temperatures.

10. The Iglinitt Project gathers records of weather conditions and other observations made by Inuit hunters and travellers. The Project uses this information to study changes in ice cover and how these changes affect Inuit communities.

11. (1) Climate influences the risk of some diseases. Lyme disease, malaria, and plague, for example, seem to increase during periods of higher temperatures. (2) Tornadoes, storms, and other extreme weather can increase the risk of injury or death. (3) Increasing temperatures can affect the amount of dust, mould, and pollen in the air, which can trigger allergies and other respiratory difficulties.

12. Overall, temperature has increased (by as much as 1.4°C) and average annual precipitation has increased.

13. a. Dissolved carbon dioxide will produce carbonic acid, which lowers the pH (in other words, increases the acidity) of the water. **b.** Increased acidity is harmful to ocean organisms. It can interfere with the reproduction of some species and the formation of shells, corals, and skeletons for other species.

14. Polar bears depend on ice for hunting grounds. Less ice makes hunting more difficult so bears might not get enough food. Bears may also have to swim farther to find prey, and consequently, have a greater risk of drowning.

15. a. There were some large fluctuations of sea ice cover (between approximately 10.6 and 9.2 million km^2) but very little net change in ice cover between 1990 and 1995. **b.** There were fluctuations between 1980 and 2005, with a net loss of over 1.5 million km^2 of ice cover. **c.** Although there are ups and downs, the overall trend is a loss of sea ice cover. I would expect this trend to continue, and that there will be more loss of sea ice cover.

16. Climate change may cause increased precipitation in some areas. Heavy rains can cause sewage systems to overflow and increase run-off from streets and fields, resulting in contamination of drinking water.

Chapter 7 Review

Earth's Climate System

Answers for page 106

Multiple Choice

1. d

2. b

3. c

4. a

5. d

6. a

7. d

8. e

Answers for page 107

Written Answer

9. The traditional lifestyle of Inuit peoples involves travelling and hunting on ice. Without the ice, travelling and hunting will be limited or impossible.

10. Both biomes and ecozones are areas defined by particular climate features and living things. An ecozone is different from a biome in that it is also defined by geologic features.

11. 1. Wetlands provide habitat for many organisms, including rare species. 2. Wetlands store and filter fresh water. 3. Wetlands help regulate climate, since wetlands support many plants, and plants remove carbon dioxide from the air through photosynthesis.

12. Deforestation affects climate by increasing the amount of carbon dioxide in the atmosphere. Trees remove carbon dioxide from the atmosphere through photosynthesis. With fewer trees, less carbon dioxide will be removed.

13. Increased temperatures worsen air quality. Dust, mould, and pollen are airborne allergens that are affected by air temperature. The number of smog days may also increase.

14. Changes in precipitation and in temperature may affect which crops can survive. Some places will get less precipitation and not be able to support crops that need more water. Other places may get more water and/or warmer temperatures and be able to grow crops that previously could not survive.

15. Wind forms from the uneven heating of Earth's surface. Warm air rises, while cool air sinks. This creates areas of pressure differences. Wind results as air moves from higher to lower pressure areas.

16. When air masses of different densities meet, one air mass rises above the other. The rising air cools, and water vapor condenses, forming precipitation. Warm moist air carried in high-altitude winds called jet streams can also result in precipitation.

Answers for page 108

17. *Sample Answer*: **a.** Improvements in disease prevention and treatment may help to address the spread of disease. Changes in agricultural and fishing practices may help address climate-related problems. Anthropogenic factors related to deforestation may be managed to help minimize forest loss. **b.** Ocean level changes, the acidity of ocean water, precipitation changes, and changes in the frequency and intensity of storms are likely out of the control of human management or technology. These are large-scale changes due to global weather and climate patterns.

18. *Sample Answer*: Some biomes, such as permanent ice zones, may disappear entirely. Other biomes may shift boundaries. The changes will depend not only on changes in temperature but also on changes in precipitation and the distribution of plants and animals.

19. Students should make a climatograph with properly labelled axes (x-axis = Month; left y-axis = Average Precipitation (cm); right y-axis = Temperature (°C)) and properly entered data. Students should include a key to indicate how precipitation and temperature are represented on the graph. The data represents a tundra biome, in which temperatures rise in the summer months and remain below zero the rest of the year. Precipitation levels are low, never above 30 mm in one month.

20. *Sample Answer*: My family farms and I plan on taking over the farm when I am older. I imagine that changes in temperature and precipitation will affect the crops we grow. There has been an overall increase in precipitation near where I live. If that continues, there is risk for increased flooding, which will also affect our farm.

21. Answers will vary. Students should use persuasive writing to express their opinion and to convince the reader to agree. Students may feel that the government should regulate the use of fossil fuels, which is one of the main anthropogenic factors in climate change, but not regulate every single human activity.

22. Students in Ontario most likely live in the temperature deciduous forest biome or in the boreal forest biome. Posters should reflect this by showing the characteristics of the biome: temperate deciduous forest—relatively unchanging amounts of precipitation throughout the year, temperatures from –30°C to 30°C, with maple, oak, and birch trees; boreal forest biome—characterized by more snow than the temperate deciduous forest and by coniferous trees such as black spruce and white spruce

23. Ontario may have fewer forests due to deforestation. There may be areas of land that become suitable for growing crops, including wheat. Air quality may worsen. Waterborne diseases may increase. Storm intensity may increase. Wetlands ecosystems may shrink as the water levels of the Great Lakes decrease.

24. Graphic organizers should show that as fossil fuel use has increased, the concentrations of resulting gases in the atmosphere has increased. These gases affect the natural processes involved in the greenhouse effect. Additionally, there have not been any geologic or other events that could explain the current climate change.

Answers for page 109

25. The more sunspots, the more solar radiation emitted. Therefore, the most solar radiation would have been emitted just before 1960.

26. The graph shows that the number of weather-related disasters in Canada has increased over the 99-year period. Significant increases have occurred since 1970.

27. *Sample Answer*: Increased average temperatures contributed to more extreme weather from 1900 to 1999.

28. I could compare average temperatures for each 10-year period with the number of weather-related disasters. If these follow the same trend, this would support the hypothesis (but would not show causation).

29. *Sample Answer*: Fossil-fuel use contributes to climate change, and climate change affects all of the world, not just particular countries. Because of the global nature of the problem, I think that there should be global regulations that all countries are required to follow.

30. *Sample Answer*: Managing current effects is important, but I think that efforts should focus on prevention of ongoing climate change. As long as climate change, we will constantly be dealing with new problems, or "symptoms," which will need new management. Only by treating the causes or sources of the problem will there be a possibility of long-term stability.

31. *Sample Answer*: A large volcanic eruption could release aerosols into the atmosphere. These reflect solar radiation and therefore result in an overall cooling effect. However, other types of volcanic eruptions can release greenhouse gases. These volcanoes may contribute to an overall rise in global temperatures.

Section 8.1 Review

Energy Transfer in the Climate System

Answers for page 110

Multiple Choice

1. d

2. b

3. a

4. d

5. b

6. d

7. a

8. b

Answers for page 111

Written Answer

9. a. Although very small amounts of matter may enter and exit Earth's atmosphere, Earth is essentially a closed system. Energy crosses the upper edge of the atmosphere, but matter, for the most part, does not. **b.** Living things are open systems. Both materials and energy enter and exit living systems. Food, gases, and water enter and waste materials and heat exit.

10. *Sample Answer*: Melting ice decreases albedo, which leads to global warming, which increases the rate of melting ice, which again decreases albedo.

11. Convection, conduction, and radiation are all types of energy transfer. Radiation is the transfer of energy, including thermal energy, as electromagnetic radiation. Conduction is the transfer of thermal energy between two objects that are in direct physical contact, from higher temperature regions to lower temperature regions. Convection is the transfer of thermal energy within liquids or gases, as highly energized molecules move from one place to another.

12. Thermohaline circulation moves thermal energy around the planet, and the exchange of thermal energy between ocean currents and the atmosphere affects climate.

13. a. Global warming could lower salinity in northern oceans as fresh water from melting ice dilutes the ocean. At the same time, increased evaporation in tropical oceans could result in higher salinity water. **b.** These changes could drastically change thermohaline circulation, because this process is driven by dense polar water sinking toward the ocean floor. If polar water is less salty, it is less dense, and therefore may be less likely to sink.

14. Both El Niño and La Niña bring changes in temperature and precipitation patterns. El Niño brings warmer than usual weather across northwestern and northeastern North America and increased rain across southern North America. Parts of southern North America are cooler than normal. In contrast, La Niña brings cooler than usual temperatures to northwestern North America and warmer than usual temperatures to southern and southeastern North America. Decreased rain occurs across southern North America, with patches of increased rain further north.

15. Thirty percent of energy leaves Earth as solar radiation. Earth has a balanced energy budget. If the incoming solar radiation represents 100 percent of Earth's energy, and 70 percent of this energy leaves as long-wave radiation, then the outgoing solar radiation must account for the remaining 30 percent.

16. a. The CERES satellites have been monitoring changes in the overall about of energy that Earth reflects or emits. **b.** To track changes in Earth's energy budget.

Section 8.2 Review

Greenhouse Gases and Human Activities

Answers for page 112

Multiple Choice

1. e

2. c

3. d

4. b

5. a

6. e

7. b

8. b

Answers for page 113

9. a

10. c

11. a

12. d

13. c

14. a

15. d

16. e

Answers for page 114

Written Answer

17. *Sample Answer*: One source is animal respiration. One sink is photosynthesis.

18. Any three of the following: bacteria break down organic material in wetlands; the digestion processes of cows and termites; landfills; processing of coal and natural gas, an tanks of liquid manure.

19. The ozone layer blocks UV radiation. A decrease in stratospheric ozone would mean an increase in the amount of UV radiation that could reach Earth. This UV radiation can cause genetic damage to organisms, including humans.

20. CFCs do not break down easily, and can remain in the atmosphere for thousands of years. Consequently, even though they are not in use, they persist in the atmosphere and continue to damage the ozone layer.

21. a. The burning of fossil fuels, deforestation, agriculture, and industrial activities have produced gases that increase the greenhouse effect. **b.** The regular greenhouse effect is a natural phenomenon that keeps Earth's climate warm and stable. The anthropogenic greenhouse effect disrupts this balance by increasing the capacity of the atmosphere to trap thermal energy. Consequently global temperatures rise.

22. GWP is a measurement of the relative impact of a greenhouse gas. The GWP of carbon dioxide is 1. All other greenhouse gases are compared to carbon dioxide.

23. *Sample Answer*: Agriculture contributes a larger percentage (7 percent) of greenhouse gases than solvents and other products (3 percent). However, some solvents are halocarbons, such as CFCs, and have a very high GWP. Although CFCs are banned, if other solvents are also halocarbons, than they may have a greater GWP than the methane released from agriculture even though the percentage of gases released is smaller.

24. Fertilizers, manure treatment, and sewage treatment are human sources of N_2O, so the waste and agriculture sectors are likely to contribute this greenhouse gas. Vehicle exhaust is another source of N_2O, and that could fit into the energy sector, because that sector includes fossil fuel consumption.

Answers for page 115

25. a. methane **b.** It could be used as a fuel. **c.** This would reduce emissions of methane, which is a greenhouse gas.

26. Ground-level ozone can cause damage to the lungs and heart, and causes rubber and plastic products to crack. Stratospheric ozone forms a layer in Earth's atmosphere that blocks ultraviolet radiation from reaching Earth's surface.

27. Any three of the following: chemical fertilizers, manure treatment, sewage treatment, or vehicle exhaust

28. No it could not be a greenhouse gas. All greenhouse gases have three or more atoms. This molecular structure accounts for their interaction with radiation.

29. Lowering the thermostat setting and improving insulation.

30. By switching to compact fluorescent light bulbs and by turning off electronics when they are not in use.

31. To reduce means to reduce the amount of materials used and disposed of. Re-using items is one way to reduce the amount of waste produced. Recycling can allow items to be repurposed instead of put into a landfill. These actions mean that less energy will be used to make more products. Also, less garbage means less greenhouse gases produced by a landfill or incinerator.

32. Halocarbons are made up of carbon and one or more halogens, such as chlorine, fluorine, or iodine.

Section 8.3 Review

Cycling of Matter and the Climate System

Answers for page 116

Multiple Choice

1. d

2. c

3. c

4. e

5. d

6. b

7. e

8. d

Answers for page 117

Written Answer

9. Through natural processes, carbon is stored in fossil fuels. The carbon could remain in these stores for hundreds of millions of years. When humans access these fossil fuels and burn them, they release these stores into the carbon cycle much more quickly than they would have through natural processes. As a result, carbon compounds build up in the atmosphere.

10. *Sample Answer*: Solid: coal, marine sediments, sedimentary rock, organic matter; Liquid: oil; Gas: natural gas, carbon dioxide, methane

11. The global carbon budget is imbalanced. In a balanced cycle, the rate of carbon entering the atmosphere would equal the rate of carbon leaving the atmosphere. Instead, carbon is entering the atmosphere faster than it is leaving, and so concentrations are increasing. Similarly, carbon is entering the ocean faster than it is leaving. This is changing the acidity of the ocean.

12. In general, modern agriculture uses large quantities of nitrogen fertilizers. This alters the nitrogen cycle by adding nitrogen into the system.

13. Nitrogen fertilizers are applies to fields. Excess nitrogen washes off into nearby waterways. The nitrogen and other wastes are concentrated at the mouths of these waterways. Algal blooms thrive on the excess nutrients. Then, as the algae decompose, oxygen in the water is used up. Organisms that require oxygen cannot survive in these regions, which become “dead zones.”

14. Precision farming involves using satellites and geographic information systems to pinpoint exact areas of a farm that require fertilization. In this way, farmers can apply fertilizer only to particular locations where it is needed. This means that less fertilizer is used, which means that less fertilizer will get washed away into water bodies.

15. a. Natural biological fixation did not change. **b.** industrial NO_x production and fertilizer production

16. conversion by lightening and bacteria

Chapter 8 Review

Dynamics of Climate Change

Answers for page 118

Multiple Choice

1. c

2. b

3. b

4. d

5. d

6. d

7. b

8. d

Answers for page 119

Written Answer

9. One reason that halocarbons have such a high GWP is because they persist indefinitely in the atmosphere.

10. a. As the salinity of water increases, the density increases. **b.** As the temperature of water in a liquid state decreases, the density increases; **c.** Because of its greater density, cold, salty water at the poles sinks to the ocean floor. This drives the overall conveyor belt of thermohaline circulation.

11. Global warming could affect ocean salinity, and changes in salinity could effect thermohaline circulation. Interruptions in thermohaline circulation could change patterns of upwelling. Upwelling brings nutrients from the sea floor up to the ocean surface, and so changes in upwelling may threaten marine species that depend on upwelling for food.

12. Earth's energy budget is balanced when incoming energy is equal to outgoing energy. A balanced budget means a stable average global temperature.

13. In general, a positive feedback loop increases or magnifies an effect while a negative feedback loop decreases of minimizes an effect.

14. The carbon cycle and the nitrogen cycle.

15. Carbon dioxide enters the atmosphere through respiration, the burning of fossil fuels, diffusing out of the ocean, the breakdown of sedimentary rock, and volcanic eruptions.

Carbon dioxide exits the atmosphere through photosynthesis and by dissolving in the ocean.

16. These animals use carbon to build their shells and other hard structures. These hard structures fall to the bottom of the ocean and build up in layers. Over time, these layers form sedimentary rock, such as chalk and limestone.

Answers for page 120

17. Phytoplankton are microscopic organisms that live in the ocean. Through photosynthesis, phytoplankton convert atmospheric carbon dioxide into sugars that then get passed along to other organisms that eat the phytoplankton.

18. approximately 160 Mt

19. by almost 200 Mt

20. *Sample Answer*: I think it is unlikely. Canada's greenhouse gas emissions rose fairly steadily between 1990 and 2007—a period of 17 years. I think that it would take longer than just a few years to reverse this rise.

21. Diagrams should show that forests are sinks for carbon, because plants remove carbon dioxide from the atmosphere through photosynthesis. Deforestation means less trees, which means less carbon removed from the atmosphere.

22. *Sample Answer*: I think that both industries and individuals should bear responsibility. Industries produce more greenhouse gases than any one individual, but individuals can take action to reduce greenhouse gases, including buying less products manufactured by industries that have high greenhouse gas emissions.

23. *Sample Answer*: We use fluorescent bulbs in all of the fixtures at home. I always recycle materials that are recyclable. I ride my bike or take the bus to school. In the future, I could walk, ride my bike, or take the bus on weekends, too.

24. The main concepts should be explained in a manner in which younger students could understand them. Students should explain what ultraviolet radiation and ozone are, why UV radiation is increasing, why stratospheric ozone decreased, and how UV radiation affects life on Earth.

Answers for page 121

25. Composting limits the materials sent to the landfill or incinerator. Landfills produce methane and incineration produces carbon dioxide. Less material sent to these disposal sites means less methane and carbon dioxide.

26. *Sample Answer*: **a.** computer, toaster oven, TV, cell phone charger, lamps, oven, clothes washer, etc. **b.** easily unplugged: toaster, TV, cell phone charger, lamps; not easily unplugged: computer, oven, clothes washer **c.** I considered the amount of time it would take to unplug and re-plug each item. Some were very easy to quickly plug and re-plug. Others required me to move large appliances or furniture.

27. Answers will vary but may focus on the idea that current climate change is caused by anthropogenic factors. The more people, the more human contribution to climate change. Issues associated with climate change would intensify with the increase in population.

28. a. methane; **b.** Unlike cows, kangaroo digestive systems do not produce methane. *Sample Answer*: **c.** In my town, kangaroo is not at all considered a food. I think that it would be difficult for people to adjust to the idea of eating this animal.

29. *Sample Answer*: I am not involved in any sort of farming or international development work, so I think that the only category that I could reasonable impact is reducing fossil fuel use. There are many different opportunities for me to modify my use of electricity, transportation, products, and other fossil fuel-using activities.

30. *Sample Answer*: I think that the efforts should focus on improving the management of livestock and the efficiency of fertilizing crops. These two actions address related sectors, and together would reduce 30 billion kg/year. I think that targeted efforts for change are more likely effective than generalized efforts. For example, although encouraging energy conservation is beneficial, the use of fossil fuels is so pervasive and varied that it could be difficult to focus conservation efforts on one specific use.

31. *Sample Answer*: Limiting fossil fuel use could also reduce air pollution, limiting respiratory health issues. Increasing the efficiency of fertilizing crops and improving livestock management could streamline work for farmers, improving the efficiency of their businesses. Providing sewage treatment for urban populations would provide public health benefits.

32. Students should make a cyclical diagram showing that a warmer atmosphere ‖ more evaporation, and that more evaporation ‖ a warmer atmosphere.

Section 9.1 Review

Discovering Past Climates

Answers for page 122

Multiple Choice

1. a

2. c

3. b

4. d

5. d

6. c

7. b

8. b

Answers for page 123

9. b

10. e

11. c

12. d

13. e

14. c

15. b

16. d

Answers for page 124

Written Answer

17. This means that the tree grew less in these years than in other years. This could suggest a stretch of time in which there was little rainfall and hot temperatures.

18. Both of these projects have drilled into ice to extract ice cores. These cores can provide data on climate records over hundreds of thousands of years.

19. A comparison of these two sets of data can provide a more complete picture of climate change in the past than could either set of data alone.

20. The temperature and humidity conditions at the time the ice formed

21. I would use ice cores. Air bubbles trapped inside the ice cores can be analyzed to find concentrations of different gases.

22. Relative concentrations of oxygen isotopes can indicate the temperature at the time the ice formed. Ice that formed when global temperatures were high, have a higher concentration of oxygen-18 than ice that formed when global temperatures were cooler.

23. Over time, Earth has gone through warming and cooling periods. In earlier warming periods, regions of Earth that are cold today—such as Antarctica—were warm and could support plants such as the fern in the fossil.

24. Students' charts should include information for each type of evidence, for example: Tree rings: floods, droughts, insect attacks, lightening strikes; Ice cores: greenhouse gas concentrations, temperature and humidity, trends in global temperatures, volcanic eruptions, forest fires, vegetation cover; Sedimentary rock: vegetation cover, rainfall and temperature patterns; Fossils: climate conditions

Answers for page 125

25. This suggests annual deposition patterns. Meltwater from the summer months washed much sediment into the lake, forming the thick light-coloured bands. Little deposition occurred over the winter months, forming the thin, dark-coloured bands.

26. Rises and falls in carbon dioxide levels closely correspond to rises and falls in temperature.

27. The data in this graph show that these two variables are closely correlated, but it does not indicate that carbon dioxide levels cause warming. It could, for example, indicate that warming causes increases in carbon dioxide. Or, a third factor that is not represented on the graph could be responsible for both carbon dioxide and temperature trends.

28. Levels of carbon dioxide were likely determined by analyzing ice cores with trapped air bubbles. Temperature trends could have been determined using evidence from ice cores, sediment cores, and fossils. The data cover hundreds of thousands of years, so it is unlikely that tree rings were used.

29. A fossil is a trace or remain of a one-living organism. Imprints of leaves, footprints, bones, teeth, shells, and even whole organisms trapped in ice or amber are all examples of fossils.

30. Evidence suggests that some past climate changes have occurred relatively quickly—within decades or less. These rapid changes may then take thousands of years to have their full effects. Other evidence suggests that some past climate changes have resulted from slow, accumulated changes in the Earth system.

31. Sediment from land washes into the oceans and lakes. Layers of sediment build up on the ocean and lake floors. Over time, the sediments become compressed and hardened into rock.

32. Scientists can get information about oxygen isotopes, which can be used to infer the temperature of the water in which the organisms lived.

Section 9.2 Review

Monitoring and Modelling Climate Change

Answers for page 126

Multiple Choice

1. d

2. c

3. a

4. e

5. e

6. c

7. b

8. c

Answers for page 127

Written Answer

9. The way in which data are gathered and the type of instruments used can affect the nature of the data, and therefore the reliability of the conclusions derived from the data.

10. Historical weather data may have been gathered in locations that were convenient, but that do not represent general conditions. They may not have been gathered systematically or recorded consistently.

11. 1. A radar instrument sends out microwaves. 2. The microwaves move through the air until they hit an object, such as rain. Then, some waves bounce back. 3. The waves that are bounced back are received by the radar, which is interpreted as precipitation.

12. Geostationary satellites orbit Earth at the same rate as Earth rotates, and therefore, remain in one location with respect to Earth. Polar orbiting satellites move north and south over the poles as Earth rotates, and therefore, monitor the entire planet.

13. The EOS is an Earth monitoring project launched in the late 1990s by Canada, the United States, and Japan. The purpose is to make long-term observations of Earth's atmosphere, oceans, land, and ecosystems to track climate trends.

14. The earlier satellites were designed primarily for weather forecasting. The newer satellites are able to perform more functions and collect more detailed data that can be used to identify trends that can give information about climate change.

15. a. Climate models are computer programs designed to analyze data about climate and predict future climate changes. **b.** The Earth system is very large and complex, and is not reasonably represented by a physical model. Computer models, however, allow processing of the large quantities of data.

16. Historical data can be used to "test" the accuracy of a climate model. The data can be entered to see what changes the model will predict. Then, these predictions can be compared to actual changes that have already occurred and been recorded. If the predictions match what actually happened, this suggests that the climate model is accurate.

Section 9.3 Review

Taking Action to Slow Climate Change

Answers for page 128

Multiple Choice

1. b

2. d

3. d

4. e

5. e

6. b

7. e

8. e

Answers for page 129

9. e

10. b

11. c

12. e

13. e

14. b

15. a

16. e

Answers for page 130

Written Answer

17. wind power, solar power, hydroelectric, tidal, nuclear power, geothermal power

18. Possible answers: hanging clothes to dry instead of using a dryer, walking or biking instead of driving, drinking tap water instead of bottled water, recycling materials instead of

throwing them away, unplug electronics when they are not in use, or taking shorter showers

19. *Sample Answer*: (1) Is the information in a respected scientific journal? This would let me know that the information was reviewed by professional scientists. (2) What is the source of the information? This would let me know if the source of the information had some stake in the issue at hand. (3) Does the author of the source have an agenda? This would let me know if the author is trying to get across a particular point, in order to serve some cause.

20. Just as the actions of billions of people have contributed to climate change, so can the actions of individuals help to slow climate change. If many individuals make small changes, the overall impact can be large.

21. To be an advocate for actions that slow climate change means to be informed and educated about climate change policies and laws, set an example in one's personal actions, and actively encourage others to support initiatives to slow climate change.

22. The overall population of Canada is much smaller than the population of India. The per person emissions are much higher in Canada, but the overall emissions are higher in India because of the larger population.

23. These countries have both large populations and high per person energy usage. Canada has high per person energy use but a much smaller population.

24. Widespread poverty on the continent means that there is limited energy use and overall limited activities that emit greenhouse gases.

Answers for page 131

25. The ecoEnergy Efficiency Initiative was started by Canada's office of Energy Efficiency. The initiative runs programs to encourage people to make homes and businesses more energy efficient. It also provides information about limiting fuel use for vehicles.

26. Replacing old products often means disposing of these items, which can add to landfill waste. Additionally, greenhouse gases were used to produce and transport the new product.

27. Although the data exist, there is not agreement of how the data should be interpreted. There are advantages and disadvantages to different approaches, and different opinions about how these should be evaluated.

28. a. household (buildings and furnishings), business, and private transport; **b.** Manufacturing would be minimized, because reusing materials means that less new products would need to be made. Clothes and personal effects may also be minimized if these items were also reused.

29. Landfills probably fall under the category of public services. In most areas, garbage is left at the curb and is picked up and transported to landfills by municipal services.

30. 19 500/365 = 53.4, so the average Canadian releases 53.4 kg of carbon dioxide each day. According to the graph, private transport accounts for 10 percent of this, so the average Canadian releases 5.3 kg of carbon dioxide each day for private transport. Note:

This may also be solved by calculating 10 percent of 19 500 = 1950. Then divide by 365 = 5.3

31. *Sample Answer*: I am very careful about reducing my home energy use. I also reuse and recycle materials, and walk or ride my bike instead of using a car. These actions likely lessen my footprint compared to the average. However, I have family in China and in Mexico and I travel at least once a year to visit both places. This travel likely increases my carbon footprint compared to the average.

32. *Sample Answer*: I think that the next national initiative should focus on lowering reliance on private transport. Private transport is one of the largest categories of Canada's carbon footprint. Reducing private transport would also have the benefit of making cities and towns less polluted and more pedestrian-friendly.

Chapter 9 Review

Addressing Climate Change

Answers for page 132

Multiple Choice

1. b

2. b

3. c

4. e

5. d

6. c

7. e

8. a

Answers for page 133

Written Answer

9. The horizontal grid represents longitude and latitude and the vertical grid represents atmospheric height and air pressure. By creating interactions between grid sections, this model can simulate how the natural climate system works.

10. Possible answers: precipitation, solar radiation, thermal radiation from Earth's surface, winds, temperature, or humidity

11. If the cells were larger, the model would be less accurate. Weather and climate vary continuously, but the model requires that the weather and climate are entered as uniform for each cell. Because of that, the smaller the cell, the closer the model is to actual conditions.

12. Organisms are adapted to the environments in which they live. By examining the types of organisms that lived in a certain region during a certain period in Earth's history, paleoclimatologists can make conclusions about the climate of the time in the regions where the organisms lived.

13. Varves show seasonal patterns in deposition, and therefore can be used to estimate rainfall and temperature patterns over a long period of time.

14. Climate models can only achieve accuracy if the data are sufficient and of sound quality. Some measurements of variables, such as solar radiation, have only recently been collected. In these cases, there is only a small set of data to work with. Other techniques for measuring have varied over the years, and therefore are not consistent.

15. With very large sets of data, the degree of precision of measurements can make huge differences in overall results. For example, a very different outcome may result when data are rounded to one decimal point compared with three decimal points or six decimal points.

16. Vegetables account for less greenhouse gas emissions than livestock. Therefore, the carbon footprint of the vegetarian would be smaller.

Answers for page 134

17. This information can help me recognize bias in the reporting. For example, if the research was conducted by a private corporation, I would want to know whether the corporation benefits depending on the results of the research. This could influence the angle that the report takes on a topic.

18. *Sample Answer*: No, I think that lifestyle changes are also required. Earth is a closed system with a fixed amount of matter, but a growing population. Over the long term, lifestyle changes will be required to successfully limit the overall carbon footprint of humans on Earth.

19. *Sample Answer*: I think that the family should replace the old refrigerator. A 10 percent energy savings is very significant over time. The family should also look into options for the disposal of the old refrigerator to see if there are eco-friendly options.

20. *Sample Answer*: I could tell my friend that overall, scientists agree that global warming is occurring and that it is caused primarily by increases in greenhouse gas emissions. It is not known by exactly how much global temperatures will rise nor what the exact effects will be.

21. The minimum change projected is a rise of about 1.4°C, and the maximum change projected is around 3.8°C.

22. The graph shows the results of many different climate models. Each model shows a slightly different pattern for projected global warming. This is because no model can predict a certainty. If models could predict certainties, there would be no difference between the predictions of each model. Models can only predict probabilities, however, so the results are slightly varied.

23. Satellites now allow for long-term observations of Earth's atmosphere, oceans, land, and ecosystems. The new generation of satellites allow for the measurements of trends that can help scientists to understand climate change, and not just forecast weather.

24. *Sample Answer*: Yes, I agree with this statement overall. Carbon footprints can be greatly affected by personal actions and choices. I think that individuals are responsible for reducing greenhouse gas emissions in proportion to their carbon footprint.

Answers for page 135

25. Tree rings can give information about hundreds or even thousands of years but do not give information about millions of years of Earth's history.

26. The bottling and transportation of the water requires energy and involves greenhouse gas emissions. The empty bottle is then either disposed of or recycled. In either case, this requires energy use. By drinking tap water, these energy expenditures are avoided.

27. *Sample Answer*: Climate change will affect many climate variables, including temperature and precipitation. Some areas will have more precipitation than in the past, while others will have less. This may affect the availability of fresh water, which could lead to new political and economic agreements about water distribution.

28. *Terra* must be a polar orbiting satellite because it monitors the entire planet and not just a single location.

29. High-income countries had much larger footprints—about 4 times greater than middle-income countries and over 6 times greater than low-income countries.

30. *Sample Answer*: This may have to do with greater per person incomes. It may also have to do with increases in energy-using technologies. Over this time period, personal vehicle use became very common. Air travel also became common. These activities account for large sections of a person's total footprint.

31. Modern developed nations rely heavily on fossil fuels to power their businesses, homes, and transportation. In that sense, economic prosperity is currently dependent on a large carbon footprint. I think that by reducing excessive use and by switching to alternative energies, continued economic prosperity may be possible without such large carbon footprints.

32. I think that it would be ethical for the countries with the largest footprints to compensate other countries that are being affected by the actions of others. This type of compensation would require the organization of an international panel to assess the effects and resulting needs of lower-income countries that are affected.

Unit 3 Review

Climate Change

Answers for page 136

Written Answer

1. *Sample Answer*: I think that the production of greenhouse gases has a larger overall impact. The addition of greenhouse gases into the atmosphere over the past few hundred years has been so rapid that I think that greenhouse gases would likely have increased even if less deforestation had occurred.

2. *Sample Answer*: Some people may not understand the scientific evidence for anthropogenic climate change. Others may be biased toward lifestyles that depend heavily on fossil fuel use. Although some people may question climate change research methods and data interpretation, most scientists accept the extensive peer-reviewed evidence.

3. Answers will vary. Students may imagine that the climate will stabilize due to reductions in carbon emissions and/or other factors. They may also imagine that global warming will continue. They should describe how the scenario they present will affect living things on Earth.

4. Students' tables could have the three biomes as column heads, with row titles such as Location, Rainfall, Snowfall, and Types of Trees. Students should fill in each cell of the table as appropriate. Location (all in Canada, but in different areas); Rainfall (temperate rainforest > temperate deciduous > coniferous); Snowfall (none in rainforest, coniferous > deciduous); Types of Trees (black and white spruce vs. maple-oak-birch vs. Sitka spruce and Douglas fir)

5. Answers will vary. *Sample Answers*: **a.** 12 600. **b.** My total emissions fit into the "good" range. **c.** I would limit my use of automobiles to reduce the total number of kilometres driven each year.

Answers for page 137

6. *Sample Answer*: Besides recycling several materials, the chart does not account for the amount of garbage produced, recreation, public services, clothes and personal effects, food and drink.

7. a. Large areas of the United States and part of Canada that were formerly viable for wheat will no longer be viable, but a new area of Canada that was previously not suitable for wheat production may now support this crop. **b.** This could be a new source of jobs and could provide food production for a changing Earth. However, the conversion of this region to agriculture would mean the destruction of forested areas. This could have negative effects to on climate, ecosystems, and culture.

8. Students' charts may include cap-and-trade systems, carbon-tax systems, ENERGY STAR® labelling, retrofitting of older buildings, upgrading appliances for efficiency, Drive Clean program, etc.

9. *Sample Answer*: Greenhouse gas emissions are the greatest forcing agent for climate change. Increases in greenhouse gas emissions parallel the human use of fossil fuels and other activities. Changes in atmospheric gases can be seen in ice cores. Deforestation has also limited the amount of carbon dioxide stored in Earth's vegetation.

10. fossil fuel emissions ‖ increases in greenhouse gases ‖ increases in carbon dioxide dissolved in the oceans ‖ formation of carbonic acid ‖ lowers pH of the water (becomes more acidic)

11. Answers will vary. Students should include content from the unit as evidence to support their arguments.

12. Student responses will vary, but should include factors such as energy transfer, hydrosphere, atmosphere, greenhouse effect, anthropogenic factors, movement of Earth in space, latitude, albedo, etc.

13. Student responses will vary but should include representations of both natural and human factors that contribute to climate change.

14. Student posters will vary but may include respiratory illness due to air pollution, waterborne diseases, tropical diseases moving into new areas, injury from increased natural disasters, or skin cancer from increased UV radiation

Answers for page 138

Literacy Test Prep

Keeping Carbon on Ice

Multiple Choice

15. a

16. d

17. d

18. b

19. d

Written Answer

20. Students should make a cyclical diagram connecting the following steps together: warmer temperatures ‖ permafrost thaw ‖ carbon emissions ‖ warmer temperatures

Answers for page 139

Literacy Test Prep

Geoengineering

Multiple Choice

21. a

22. d

23. c

24. b

25. c

Written Answer

26. *Sample Answer*: Scientists may be concerned about unforeseen outcomes. The Earth climate system is very complex and the manipulation of one variable may have many outcomes, for example, changes in wind patterns, ocean currents, and precipitation. Other concerns may include: overcooling, expense, that it will be ineffective, etc.