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D1.1 Check and Reflect

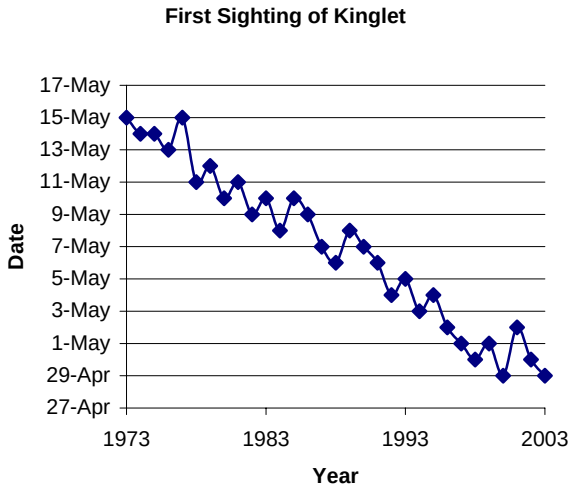
1. a) weather
   b) climate
2. Weather is the day-to-day conditions of temperature and precipitation. Climate is the average weather conditions over a period of time, usually a minimum of 30 years.
3. Students should list the key features of the lithosphere, hydrosphere, and atmosphere.
4. The troposphere is the atmospheric layer found from Earth's surface to about 10 km above, and contains about 80% of the atmospheric gases by mass. The troposphere is the only layer that has sufficient oxygen to support human life, contains most of the carbon dioxide and water vapour, and is where most weather occurs.
5. Nitrogen is the most abundant gas in Earth's atmosphere (78%).
6. The layers of the atmosphere are classified by temperature range. The global average temperature range with increasing altitude is: in the troposphere, +15°C to –60°C; in the stratosphere, –60°C to 0°C; in the mesosphere, 0°C to –100°C; and in the thermosphere, –100°C to +1500°C.
7. Troposphere
8. No, since the lithosphere encompasses the land making up Earth's continents and the land under the oceans and other large bodies of water.
9. The stratosphere contains most of the ozone gas in the atmosphere, which absorbs large amounts of energy from the Sun's rays. The temperature in the stratosphere therefore increases with altitude.
10. Students should disagree with the statement: the hydrosphere comprises all of Earth's water, including that present as frozen water or water vapour.
11. Students' charts may be similar to that shown here:

Similarities		
Lithosphere	**Hydrosphere**	**Atmosphere**
• part of biosphere • interacts with other components of biosphere • provides conditions that support life	• part of biosphere • interacts with other components of biosphere • provides conditions that support life	• part of biosphere • interacts with other components of biosphere • provides conditions that support life
Differences		
Lithosphere	**Hydrosphere**	**Atmosphere**
• composed of mixture of solids • is Earth's surface and about 100 km below	• composed of only water in solid, liquid, or gas phase • is mainly on Earth's surface (97% is in oceans)	• composed of mixture of gases, in layers • is above Earth's surface

12. The purpose of this question is to reinforce that the biosphere is more than three non-living components. Students should be able to answer this with background from junior high school: i.e., the atmosphere contains gases, such as oxygen and carbon dioxide, that plants and animals need for life; all living things require water from the hydrosphere; and the lithosphere contains the elements that make up the compounds for building cells.
13. Students will likely construct a bar or pie graph to illustrate the differences in the two atmospheres. Students' graphs should show that the only similarity between the atmospheres of Earth and Saturn is in the 1% occupied by other gases. The differences are: the main gases in Earth's atmosphere, nitrogen and oxygen, are absent in Saturn's atmosphere and the main gases in Saturn's atmosphere, hydrogen and helium, are trace gases in Earth's atmosphere. Our atmosphere is the only one in the solar system to provide sufficient oxygen to support life as we know it.
14. Students' letters should draw upon the ideas covered in this lesson. The letters should identify the features of the part of the biosphere that students choose and why they are of particular interest. A good letter may include specific questions or issues that the student would like to address, such as the relationship between climate and the range(s) of particular plants and animals.

D1.2 Check and Reflect

1. Students' answers will vary but may include effects on clothing, housing, and diet.
2. Students' answers may include a description of changes in grizzly behaviour, such as winter inactivity versus summer activity, or of the bears' weight, which increases during summer and falls during winter. If students choose other animals, answers should reflect similar adaptations to climate, such as the change in fur colour of Arctic hares.
3. Since trumpeter swans require wetlands in order to reproduce, they would be unable to survive in a hot, dry climate.
4. Climate change is a change in the climate of a region that occurs over a period of time, usually a minimum of 30 years.
5. Scientists use time periods of at least 30 years to study climate change because there can be a great deal of variation in weather conditions from year to year that is unrelated to climate change. Time periods shorter than 30 years are insufficient to determine if changes reflect climate change, or just periods of warmer or cooler weather.
6. Anecdotal evidence is any observation(s) that has not been tested to ensure it is unbiased and is applicable to situations other than the particular events reported. Examples of anecdotal evidence will vary, and may include reports from aboriginal elders or from farmers. In contrast, scientific evidence is collected in a manner that, as much as possible, ensures that the observation(s) is unbiased and describes general situations, instead of just particular events. Examples will vary and may include temperature data or ice core data.
7. Students' letters should demonstrate that they understand how local climate conditions affect clothing needs and recreational opportunities. Suggestions of winter sports may include hockey, skiing, or skating, and summer sports may include swimming, cycling, or soccer.
8. a) Students' graphs will vary. A sample line graph appears below:



   b) The first sighting of the bird is becoming earlier in the year over time.
   c) Answers may vary. Students may suggest that the climate is changing so that spring is coming earlier, or that the average temperature is increasing due to climate change.
   d) Answers will vary, but should reflect an understanding that evidence of climate change must include observations over at least 30 years. Suggestions may include gathering weather data over the last 30 years or more, collecting data on the sightings of other migratory birds, looking at tree rings for evidence of a warming trend, or looking for changes in the pattern of first flowering of particular plant species in spring.
9. Students' research should discuss the impact of changing conditions on native plants. Plants that are adapted to dry conditions are often unable to survive in the wetter conditions of irrigated land, and so become less prevalent. The Okanagan region was once distinguished by species such as ponderosa pine and bunchgrass. Since native plants are adapted to the natural, dry conditions of the Okanagan, student may suggest that these plants will again become more prevalent if conditions become drier. Others will suggest that these plants may die out due to the reduced moisture levels in the non-irrigated areas they inhabit, whereas the plants in irrigated regions will continue to thrive due to human intervention. To assess answers to this question, you may wish to use Assessment Rubric (22) Student Products: Research Paper/Project.

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D1.0 Section Review

Knowledge

1. The biosphere is a relatively thin layer of Earth that has conditions suitable for supporting life, as we know it. The biosphere is composed of all the living things on Earth and the physical environment that supports them.
2. Weather refers to the conditions of temperature, air pressure, cloud cover, precipitation, and humidity that occur at a particular place at a particular time. Climate is the average weather conditions that occur in an area over a long period of time, usually a minimum of 30 years.
3. The atmosphere is the layer of gases that surround Earth. The lithosphere is the solid portion of Earth, composed of rocks, minerals, and elements. The hydrosphere is all the water on Earth, whether present as liquid, water vapour, or ice.
4. The troposphere is the only layer with sufficient oxygen and an appropriate temperature range to support human life.
5. The ozone layer is found in the stratosphere.
6. Almost all of Earth's atmospheric dust is found in the troposphere.
7. Oxygen gas and carbon dioxide gas are the most important in supporting life on Earth.
8. The lithosphere is warmed mainly by energy from the Sun, and a small amount by molten material under the lithosphere.
9. Water can be found in large bodies of water such as oceans, lakes, and streams, in soil in the lithosphere, as water vapour in the atmosphere, and frozen water in ice and snow, and in the cells of living organisms.
10. Answers will vary. One example of climate affecting animals is the need of some animals to hibernate or to migrate during the winter.
11. Anecdotal evidence relies on reports from people about particular events and how these people interpret these events. Anecdotal evidence has not been carefully tested to ensure it is unbiased and is applicable to situations beyond the particular events. Scientific evidence relies on evident collected in a manner that ensures it is unbiased and reflective of general situations (rather than particular events). Scientific evidence is usually collected by trained scientists and checked by other scientists.
12. a) scientific
    b) anecdotal
    c) anecdotal
    d) scientific

Applications

13. It is difficult to include water vapour in a chart of Earth's atmosphere because the amount of water vapour is always changing.
14. a) hot and dry, 1959–1963, 1965; 1967–1968; cool and wet, 1964 and 1966
    b) Increasing the number of trees in the study increases the accuracy of the data. Data from only two trees can be skewed depending on other conditions in their specific locations.
    c) Anecdotal evidence. Anecdotal evidence is often used to confirm or extend scientific data, especially in weather and climate studies where historical scientific evidence may be absent.
    d) No, because climate change occurs over a long period of time, usually at least 30 years.

Extensions

15. Students' models are likely to be similar to Figure D1.2 on page 343, but with the specific features of topography and plant and animal species found in your locale.
16. Students' presentations should focus on a plant or animal native to Alberta, and how it is adapted to specific climate conditions. Students are expected to research the distribution of the species and the particular climate conditions in this range, and then make connections between the two. Students may use drawing or graphing technology to create their electronic presentation.
17. Students' diagrams should include differences in materials used and methods needed to retain heat or to maximize heat loss, and may also discuss aspects such as the existence of cellars or basements. You may wish to use Assessment Rubric (14) Scientific Skills and Processes: Diagrams, to assist you in evaluating the diagrams.

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D2.1 Check and Reflect

1. The North Pole receives relatively high amounts of solar energy from Mar. to Sept., and low amounts of solar energy from Sept. to Mar. The South Pole shows the reverse pattern; it receives relatively high amounts of solar energy from Sept. to Mar., and low amounts from Mar. to Oct.

2. Cloud cover reflects and absorbs incoming solar energy, which reduces the amount of solar energy that reaches Earth's surface.
3. Albedo is determined by the reflectivity (shininess) of a surface.
4. The electromagnetic spectrum is the range of wavelengths of energy radiated by the Sun (solar energy).
5. The sources of energy that reach the troposphere include the incoming solar energy and the thermal energy emitted from Earth's surface. Some students will note that the amount of incoming solar energy is reduced by the amount reflected by outer layers of atmosphere and increased by any solar energy reflected from Earth's surface.
6. Earth's net radiation budget is the difference between incoming radiation and outgoing radiation from Earth's surface.
7. The North Pole receives the greatest amount of insolation on June 21–22, at its summer solstice. At the same time, the South Pole is experiencing its winter solstice, and receives the lowest amount of insolation.
8. The albedo of an area that is covered with snow will be higher than that of an area covered with dark soil.
9. Solar energy absorbed by Earth's surface is eventually re-emitted and radiated into space as thermal energy. Some students may include the percent contributions to the net radiation budget: 64% emitted by clouds and atmospheric gases, 23% by phase changes in the hydrosphere, 7% by the action of global winds, and 6% directly from Earth's surface.
10. The angle of inclination is the tilt of Earth's axis from the perpendicular of the plane of its orbit (23.5°). The angle of incidence is the angle between a ray falling on a surface and the line of the perpendicular to that surface.
11. Solar energy reaching Earth's surface that is not reflected back into space is absorbed. Students may note that this energy is converted to thermal energy. Some may also state that a small amount is used for photosynthesis.
12. Factors that affect the amount of solar radiation that reaches a region of Earth's surface include the latitude of the region, and the amount of dust and cloud cover.
13. Students' answers should discuss the fact that the angle of inclination causes seasonal changes in the length of daylight with latitude.
14. Students' tables should contain the following information:

Date	Ynnus	Ywons
December 21 (solstice)	• most hours of daylight • most amount of insolation	• fewest hours of daylight • least amount of insolation
March 21 (equinox)	• number of daylight hours is equal to number of hours of night • insolation is at median for the region	• number of daylight hours is equal to number of hours of night • insolation is at median for the region

15. Students' illustrations should show that the gases of the atmosphere absorb radiation re-emitted from Earth's surface.
16. Students are expected to discuss the differences in albedo in these three cities, and how albedo affects absorption of solar energy. In the summer, Rocky Peaks will have the lowest albedo and so will absorb the most solar energy. As a result, Rocky Peaks will have the highest average temperature in summer and in winter.
17. Students' illustrations should show how the albedo, angle of incidence, amount of greenhouse gases, particles, and clouds influence the amount of solar radiation reaching the surface of Earth. Illustrations should clearly indicate the features of your region that affect these factors, particularly albedo and latitude.
18. The albedo of the water will vary with changes in the water surface that result from local weather conditions. Waves, for example, will influence how much light is reflected.

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D2.2 Check and Reflect

1. Unequal distribution of thermal energy on Earth leads to relatively high average atmospheric temperatures in equatorial regions, and relatively low average atmospheric temperatures in polar regions. Students may note that this temperature differential causes convection currents, which drive global winds.
2. Three methods of thermal energy transfer are radiation, convection, and conduction.
3. Both convection and conduction transfer thermal energy. Convection occurs most often in fluids, and transfers thermal energy by changes in the location of particles. Conduction occurs most often in solids, and transfers thermal energy by

direct contact between particles, without any changes in location.

4. Global winds transfer thermal energy.
5. Air moves from areas of high pressure to areas of low pressure because air at high pressure is denser than air at low pressure.
6. The Coriolis effect is the deflection of an object from a straight-line path by the rotation of Earth. The Coriolis effect is responsible for the global patterns in the direction of wind.
7. In the Northern Hemisphere, the Coriolis effect causes winds to be deflected to the right for a person facing south toward the equator, or to the left for a person facing north toward the North Pole.
8. The trade winds are global winds that tend to blow eastward. They occur in a band around Earth above and below the equator.
9. Jet streams are bands of fast-moving air found in the stratosphere.
10. Jet streams occur in the stratosphere, well above Earth's surface, and so encounter much less friction than other global winds. As a result, they are faster than other global winds.
11. Students' diagrams should show that convection currents transfer thermal energy from a region at high temperature to a region at low temperature.
12. When a high-pressure system is approaching from the west, wind will blow westward, since air always moves from regions at high pressure into regions at low pressure.
13. Thermal energy transfer always occurs from regions of high temperature to regions of low temperature. Equatorial regions receive the most insolation, so the average air temperature at the equator is higher than at other regions on Earth. The air temperature at the poles is always relatively cold, since the poles receive the least average insolation of any region on Earth. Air is therefore heated at the equator, which causes it to expand and becomes less dense. The heated air rises in the atmosphere, and the upward convection current moves it toward the poles.
14. Students' illustrations should be similar to Figure D2.21 on page 373, but the direction of the arrows will change to show a westward path of deflection from the equator towards the North Pole. Yes, the path of deflection would still be westward for a path from the equator to the South Pole, since it is also subject to the direction of Earth's rotation.
15. Students' answers may vary, but should refer to the fact that thermal energy transfer by conduction requires direct contact between particles. Without convection, there would be no global winds, and so, far less transfer of thermal energy between the equator and the poles. A sample answer is that if it relied on conduction in the atmosphere, thermal energy transfer could occur only at points where gas molecules in the air were in direct contact with molecules in the lithosphere or hydrosphere.
16. A planet that did not rotate would not be subject to the Coriolis effect. As a result, the planet would be subject to convection currents running north and south between the equator and the poles, similar to the diagram in Figure D2.20 on page 372.
17. The trade winds are easterly winds, and so would offer sailing vessels steady winds to travel from Europe to South America, across the Atlantic Ocean. The return trip could be made following the westerlies. Some students may compare the use of the trade winds in former times to the current use of the jet streams.

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Practice Problems

Example Problem D2.1

1. Calculate the change in temperature, Δt, from the given data:

   $\Delta t = 22.0^{\circ}C - 4.00^{\circ}C$

   $= 18.0^{\circ}C$

   Calculate the quantity of thermal energy, Q, using the formula:

   $Q = mc\Delta t$

   $= (200\ g)(4.19\ \frac{J}{g \cdot {}^{\circ}C})(18.0\ {}^{\circ}C)$

   $= 15\ 084\ J$

   $= 15.1\ kJ$

   When 200 g of water at 4.00°C warms to 22.0°C, 15.1 kJ of thermal energy is absorbed.

2. Calculate the change in temperature, Δt, from the given data:

   $\Delta t = 100.0^{\circ}C - 23.0^{\circ}C$

   $= 77.0^{\circ}C$

   Calculate the quantity of thermal energy, Q, using the formula:

   $Q = mc\Delta t$

   $= (100.0\ g)(4.19\ \frac{J}{g \cdot {}^{\circ}C})(77.0\ {}^{\circ}C)$

   $= 32\ 263J$

   $= 32.3\ kJ$

   Increasing the temperature of 100.0 g of water at 23.0°C to 100.0°C would require 32.3 kJ of thermal energy.

Example Problem D2.2

3. Calculate the quantity of thermal energy, Q, using the formula:

$Q = mc\Delta t$

$= (20.0\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})(15.0^\circ\text{C})$

$= 1257\ \text{J}$

$= 1.26\ \text{kJ}$

To decrease the temperature of 20.0 g of water by 15.0°C, 1.26 kJ of thermal energy must be released.

4. Calculate the change in temperature, Δt, from the given data:

$\Delta t = 0.00^\circ\text{C} - (-15.0^\circ\text{C})$

$= 15.0^\circ\text{C}$

Calculate the quantity of thermal energy, Q, using the formula:

$Q = mc\Delta t$

$= (1000\ \text{g})(2.00\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})(15.0^\circ\text{C})$

$= 30\ 000\ \text{J}$

$= 30.0\ \text{kJ}$

To warm 1.00 kg of water at –15.0°C to 0.0°C, 30.0 kJ of thermal energy is required.

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Practice Problems

Example Problem D2.3

5. The amount of thermal energy added, Q, is 255 kJ, or 255 000 J. The mass, m, is 3.0 kg or 3000 g.

Rearrange the formula for the quantity of thermal energy, Q, to solve for change in temperature, Δt.

$Q = mc\Delta t$

or, $\Delta t = \frac{Q}{mc}$

$= \frac{255\,000\ \text{J}}{(3000\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})}$

$= 20.286\,396^\circ\text{C}$

$= 20^\circ\text{C}$

When 3.0 kg of water absorbs 255 kJ of thermal energy, it increases in temperature by 20°C.

6. The mass, m, of water and of iron is 1.00 kg, or 1000 g.

Rearrange the formula for the quantity of thermal energy, Q, to solve for the change in temperature, Δt, of water:

$Q = mc\Delta t$

or, $\Delta t = \frac{Q}{mc}$

$= \frac{500\ \text{J}}{(1000\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})}$

$= 0.119\,331\,7^\circ\text{C}$

$= 0.199^\circ\text{C}$

Then, use the same rearranged formula to calculate the change in temperature, Δt, of iron:

$\Delta t = \frac{Q}{mc}$

$= \frac{500\ \text{J}}{(1000\ \text{g})(0.449\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})}$

$= 1.113\,585\,7^\circ\text{C}$

$= 1.11^\circ\text{C}$

When 500 J of thermal energy are added to 1.00 kg of water, the temperature changes by 0.199°C. When 500 J of thermal energy are added to the same mass of iron, the temperature changes by 1.11°C.

Example Problem D2.4

7. Rearrange the formula for the quantity of thermal energy, Q, to solve for specific heat capacity, c:

$Q = mc\Delta t$

or, $c = \frac{Q}{m\Delta t}$

$= \frac{574\ \text{J}}{(20.0\ \text{g})(32.0^\circ\text{C})}$

$= 0.896\,875\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$

$= 0.897\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$

The experimental specific heat capacity of aluminium is 0.897 J/g·°C.

8. The quantity of thermal energy, Q, added is 1.95 kJ, or 1950 J.
Rearrange the formula for the quantity of thermal energy, Q, to solve for specific heat capacity, c:

$$Q = mc\Delta t$$

$$\text{or, } c = \frac{Q}{m\Delta t}$$

$$= \frac{1950\ \text{J}}{(1000\ \text{g})(15.0^\circ\text{C})}$$

$$= 0.13\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$$

$$= 0.130\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$$

The experimental specific heat capacity of the object is 0.130 J/g·°C.

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Practice Problems

Example Problem D2.5

9. Calculate the experimental heat of fusion, H_{fus}, using the formula:

$$H_{fus} = \frac{Q}{n}$$

$$= \frac{0.751\ \text{kJ}}{0.125\ \text{mol}}$$

$$= 6.008\ \frac{\text{kJ}}{\text{mol}}$$

$$= 6.01\ \frac{\text{kJ}}{\text{mol}}$$

The experimental heat of fusion of ice is 6.01 kJ/mol.

10. Rearrange the formula for the heat of fusion, H_{fus}, to solve for the amount of thermal energy, Q:

$$H_{fus} = \frac{Q}{n}$$

$$\text{or, } Q = H_{fus}n$$

$$= (6.01\ \frac{\text{kJ}}{\cancel{\text{mol}}})(3.20\ \cancel{\text{mol}})$$

$$= 19.232\ \text{kJ}$$

$$= 19.2\ \text{kJ}$$

To melt 3.20 mol of ice at 0.0°C requires 19.2 kJ of thermal energy.

11. Rearrange the formula for the heat of fusion, H_{fus} to solve for the amount of ice in moles, n:

$$H_{fus} = \frac{Q}{n}$$

$$\text{or, } n = \frac{Q}{H_{fus}}$$

$$= \frac{15.0\ \cancel{\text{kJ}}}{6.01\ \frac{\cancel{\text{kJ}}}{\text{mol}}}$$

$$= 2.495\,840\,2\ \text{mol}$$

$$= 2.50\ \text{mol}$$

Addition of 15.0 kJ of thermal energy will melt 2.50 mol of ice at 0.0°C.

Example Problem D2.6

12. Determine the number of moles, n, in 100 g of copper using the formula:

$$n = \frac{m}{M}$$

$$= \frac{100\ \text{g}}{63.55\ \frac{\text{g}}{\text{mol}}}$$

$$= 1.573\,564\,1\ \text{mol}$$

Calculate the experimental heat of fusion, H_{fus}, using the formula:

$$H_{fus} = \frac{Q}{n}$$

$$= \frac{0.606\ \text{kJ}}{1.573\,564\,1\ \text{mol}}$$

$$= 0.385\,113\ \frac{\text{kJ}}{\text{mol}}$$

$$= 0.385\ \frac{\text{kJ}}{\text{mol}}$$

The experimental heat of fusion of copper is 0.385 kJ/mol.

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Practice Problems

Example Problem D2.7

13. Calculate the experimental heat of vaporization, H_{vap}, using the formula:

$$H_{vap} = \frac{Q}{n}$$

$$= \frac{8.70\ \text{kJ}}{2.50\ \text{mol}}$$

$$= 3.48\ \frac{\text{kJ}}{\text{mol}}$$

The experimental heat of vaporization of methanol is 3.48 kJ/mol.

14. First, determine the number of moles, n, in 250 g of water:

$$n = \frac{m}{M}$$
$$= \frac{250\ \text{g}}{18.02\ \frac{\text{g}}{\text{mol}}}$$
$$= 13.873\,473\ \text{mol}$$

Then, calculate the experimental heat of vaporization, H_{vap}, using the formula:

$$H_{vap} = \frac{Q}{n}$$
$$= \frac{564.0\ \text{kJ}}{13.873\,473\ \text{mol}}$$
$$= 0.40.653122\ \frac{\text{kJ}}{\text{mol}}$$
$$= 40.7\ \frac{\text{kJ}}{\text{mol}}$$

The experimental heat of vaporization of water is 40.7 kJ/mol.

15. First, determine the number of moles, n, in 500 g of water:

$$n = \frac{m}{M}$$
$$= \frac{500\ \text{g}}{18.02\ \frac{\text{g}}{\text{mol}}}$$
$$= 27.746\,947\ \text{mol}$$

Then, rearrange the formula for the heat of vaporization, H_{vap}, to solve for the amount of thermal energy, Q:

$$H_{vap} = \frac{Q}{n}$$
or, $$Q = H_{vap} n$$
$$= (40.65\ \frac{\text{kJ}}{\cancel{\text{mol}}})(27.746\,947\ \cancel{\text{mol}})$$
$$= 1127.9133\ \text{kJ}$$
$$= 1.13 \times 10^3\ \text{kJ}$$

To change the phase of 500 g of water at 100.0°C from liquid to vapour requires 1.13×10^3 kJ of thermal energy.

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D2.3 Check and Reflect

1. In the hydrosphere, thermal energy is transferred from the warmer latitudes near the equator to the cooler latitudes near the poles, through the actions of surface ocean currents and the hydrologic cycle.
2. Students' diagrams of the stages of the water cycle will likely be similar to Figure D2.27 on page 383.
3. Sources of water vapour in the atmosphere include evaporation from land, lakes, and rivers, respiration by plants and animals, and transpiration from plants.
4. About 70% of Earth's surface is covered with water.
5. Pie charts should show 90% of water vapour coming from large bodies of water, and the remaining 10% from all other sources.
6. Specific heat capacity of a substance is the amount of energy needed to raise the temperature of 1 g of that substance by 1^oC.
7. Students should refer to the factors included in the equation $Q = mc\Delta t$. Therefore, to determine specific heat capacity, one must consider the mass, m, the quantity of thermal energy, Q, and the change in temperature, Δt.
8. Water will contain the greater quantity of thermal energy, due to its higher specific heat capacity. Since equal masses of both substances are used, students need not perform a calculation to answer the question.
9. $H_{fus} = Q/n$, where H_{fus} is the heat of fusion, Q is the quantity of thermal energy, and n is the number of moles.
10. The heat of vaporization of a substance is the amount of thermal energy absorbed when 1 mol of that substance changes from liquid phase to vapour phase, without a change in temperature.
11. The heat of fusion of a substance is the amount of thermal energy released when 1 mol of the substance changes from liquid phase to solid phase, without a change in temperature, whereas the heat of vaporization is the amount of thermal energy absorbed when 1 mol of a substance changes from liquid phase to vapour phase, without a change in temperature.
12. The global ocean currents are driven by the global winds, so they show a similar pattern of direction, and are both subject to the Coriolis effect. Both global wind patterns and global ocean current patterns transfer thermal energy from the equator to the poles.
13. Since water has a high specific heat capacity, the cold ocean currents on the west of the island will tend to cool coastal areas, whereas the warm ocean currents on the east will tend to warm coastal areas. As a result, the city on the east coast would have the warmest average annual temperature, since all other factors are equal.

14. Calculate the change of temperature, Δt, from the given data:

$\Delta t = 80.0°C - 20.0°C$

$= 60.0°C$

The mass of aluminium is 3.0 kg, or 3000 g.

Calculate the quantity of thermal energy, Q, using the formula:

$Q = mc\Delta t$

$= (3000\ \text{g})(0.897\ \frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}})(60.0°\text{C})$

$= 161\ 460\ \text{J}$

$= 1.6 \times 10^5\ \text{J}$

$= 1.6 \times 10^2\ \text{kJ}$

Increasing the temperature of 3.0 kg of aluminium from 20.0°C to 80.0°C requires 1.6×10^2 kJ of thermal energy.

15. The mass, m, of water is 2.00 kg, or 2000 g.

Calculate the quantity of thermal energy, Q, using the formula:

$Q = mc\Delta t$

$= (2000\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}})(20.0°\text{C})$

$= 167600\ \text{J}$

$= 1.68 \times 10^5\ \text{J}$

$= 168\ \text{kJ}$

Increasing the temperature of 2.00 kg of water by 20.0°C requires 168 kJ of thermal energy.

16. Rearrange the formula for the quantity of thermal energy, Q, to solve for change in temperature, Δt,

$Q = mc\Delta t$

or, $\Delta t = \frac{Q}{mc}$

$= \frac{13.5\ \text{J}}{(2.50\ \text{g})(0.449\ \frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}})}$

$= 12.026\ 726\ ^\circ\text{C}$

Calculate the final temperature, using the given and calculated data:

Final temperature $= 24.0°\text{C} + \Delta t$

$= 24.0°\text{C} + 12.026\ 726°\text{C}$

$= 36.026\ 726°\text{C}$

$= 36.0°\text{C}$

When 2.50 g of iron at 24.0°C absorbs 13.5 J of thermal energy, the final temperature is 36.0°C.

17. Rearrange the formula for the quantity of thermal energy, Q, to solve for mass, m;

$Q = mc\Delta t$

or, $m = \frac{Q}{c\Delta t}$

$= \frac{60.0\ \text{J}}{(0.385\ \frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}})(10.4\ ^\circ\text{C})}$

$= 14.985\ 01\ \text{g}$

$= 15.0\ \text{g}$

A 15.0-g mass of copper was heated.

18. Calculate H_{vap} using the formula:

$H_{vap} = \frac{Q}{n}$

$= \frac{81.4\ \text{kJ}}{2.00\ \text{mol}}$

$= 40.7\ \frac{\text{kJ}}{\text{mol}}$

The experimental heat of vaporization of water is 40.7 kJ/mol.

19. A 100.0 g mass of liquid water at 100.0°C contains less thermal energy than a 100.0 g mass of water vapour at 100.0°C because, when the liquid water changes phase to water vapour, the bonds between the water molecules absorb an amount of thermal energy equivalent to the heat of vaporization of water (40.65 kJ/mol).

20. First determine the number of moles, m, in 45.0 g of ice using the formula:

$n = \frac{m}{M}$

$= \frac{45.0\ \text{g}}{18.02\ \frac{\text{g}}{\text{mol}}}$

$= 2.497\ 225\ 3\ \text{mol}$

Rearrange the formula for the heat of fusion, H_{fus}, to solve for the amount of thermal energy, Q:

$H_{fus} = \frac{Q}{n}$

or, $Q = H_{fus}n$

$= (2.497\ 225\ 3\ \cancel{\text{mol}})(6.01\frac{\text{kJ}}{\cancel{\text{mol}}})$

$= 15.008\ 324\ \text{kJ}$

$= 15.0\ \text{kJ}$

When 45.0 g of ice at 0.00°C melts, it absorbs 15.0 kJ of thermal energy.

21. Rearrange the formula for the heat of vaporization, H_{vap}, to solve for the number of moles, n:

$$H_{vap} = \frac{Q}{n}$$

$$\text{or, } n = \frac{Q}{H_{vap}}$$

$$= \frac{488 \text{ kJ}}{40.65 \frac{\text{kJ}}{\text{mol}}}$$

$$= 12.004\,92 \text{ mol}$$

$$= 12.0 \text{ mol}$$

When liquid water at 100.0°C absorbs 488 kJ of thermal energy, 12.0 mol of water will enter the vapour phase.

22. Water has a high specific heat capacity, so it heats and cools slowly. In the spring, the water would have a low initial temperature and must absorb a large quantity of solar energy before it increases in temperature. In the fall, the lake would be at a higher temperature, since it would have absorbed solar energy throughout the summer. It must release a large quantity of thermal energy before it decreases in temperature. As a result, the water in a given lake will be warmer in fall than in spring.
23. Temperature does not change until a substance has completed changing phase. The temperature of the water will remain at 0ºC until all the ice is melted because the bonds that hold the water molecules in the solid phase absorb all the energy, until they become sufficiently weak that the water enters the liquid phase.

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D2.4 Check and Reflect

1. A biome is a large geographical region with a particular range of temperature and precipitation levels, and the plants and animals that are adapted to those climate conditions.
2. A biome is an open system in that energy, such as solar and thermal energy, and matter, such as carbon, oxygen, and water, are exchanged with the surroundings of the system.
3. The surroundings of a biome include everything that is outside the biome.
4. Dividing Earth into biomes helps scientists to study and understand the interactions between the living and non-living components of each biome, and how biomes interact with one another. Biome divisions also make it easier to predict how different groups of organisms may be affected by changes in that region.
5. Students' answers will vary with the geographical location in which they live. Answers should name the biome of your local area, and include a description of the average conditions of temperature and precipitation during the year and of the native plants and animals of the region.
6. Desert and tundra biomes
7. Answers will vary, but should focus on the differences between a prairie and a savannah grassland. Prairie grasslands are significantly cooler, so the plants and animals adapted to these biomes have adaptations to cope with cold winter conditions. Savannah grasslands are warmer and have a wet season rather than winter. This allows a few scattered trees to grow. The animals of these regions are significantly different, due to geographic isolation.
8. a) rain forest
   b) taiga
   c) deciduous forest
   d) desert
   e) tundra
9. Students' paragraphs should include most of the following points. Biomes and cells both exchange energy and matter with their surroundings. Biomes and cells both allow matter to move into and out of their boundaries. Biomes and cells both need energy to survive, which is provided from outside the system. If the availability of energy or matter in the surroundings changes too much, both cells and biomes may become unable to function.
10. Students' maps should show the different biomes in the province, taiga and grassland. Examples of plants and animals indigenous to the biomes of Alberta will vary.
11. Students' answers will vary, but should show evidence of understanding that all the organisms in a biome are affected by any change in climate. Some may argue that dry grassland biomes would be most affected, since water is already limited. Others may argue that taiga biomes would be most affected, since habitat for wild species might be reduced. Encourage students to also consider the impact on the humans in the biome they choose. This question can be used as a short research project, in which students use newspapers, magazines, journals, and/or interviews with affected persons to prepare a report or presentation.

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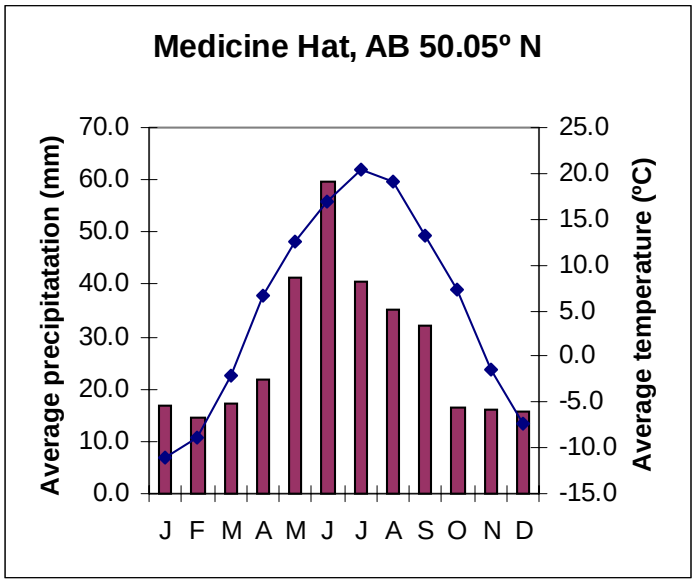
D2.5 Check and Reflect

1. Factors that play a role in determining the climate of an area include the insolation, the pattern of global winds that prevail over the area, and the pattern of warm and cold currents for coastal areas or the presence of any large bodies of water.
2. A climatograph is a graphical summary of the monthly average precipitation and temperature in a particular location.
3. Precipitation and temperature
4. A coastal region would have a significantly different climate from an inland region at the same latitude because of the moderating effect of large bodies of water. Water has a higher specific heat capacity than the land or air, so warm bodies of water tend to warm the regions close by, and cool bodies of water tend to cool nearby regions.
5. Students should produce climatographs of Medicine Hat similar to that shown here:



6. Student answers will vary, but could include differences in altitude, proximity to water, or the effect of global winds.
7. Insolation is determined mainly by latitude. There is a progressive decrease in insolation from the equator north and south to polar regions. More local differences in albedo, cloud cover, atmospheric dust, and prevailing winds will modify the amount of insolation.
8. No, since a climatograph is prepared from data of average climatic conditions over many years. As a result, extreme weather events would not cause a significant change in a climatograph.
9. Precipitation is highest during the warmest months (approximately May to September) and lowest during the coldest months (approximately October to February).
10. Students' answers will vary but should include references to the vegetation being cold hardy and not needing high moisture levels to survive.
11. Students' answers will depend on the cities they select. Have students compare the cities using the steps 2a to 2f in Activity D17 Inquiry Lab: Using Climatographs to Compare Biomes.

Student Book pages 408–409

D2.0 Section Review

Knowledge

1. Angle of inclination and angle of incidence
2. The albedo of snow is higher than that of forest because it reflects more radiation.
3. net radiation budget =
   incoming radiation – outgoing radiation
4. Most infrared radiation is absorbed in the atmosphere, by the natural greenhouse effect.
5. The natural greenhouse effect warms the atmosphere and creates the conditions of climate that make life possible on Earth.
6. An albedo of 0.3 means that, on average, 30% of all incoming radiation hitting Earth's surface is reflected back into space.
7. The thermal energy absorbed by the lithosphere is re-emitted as thermal energy. The atmosphere then absorbs some of this re-emitted thermal energy, and the rest escapes back into space.
8. Air moves from areas of high pressure to areas of low pressure.
9. The Coriolis effect causes global winds to be deflected from the straight-line path from the equator to the poles.
10. Thermal energy is transferred in the hydrosphere from the equator to the poles.
11. Students should describe how water evaporates into the atmosphere or is released by plants through transpiration, and then condenses in the atmosphere to return to the lithosphere or hydrosphere as precipitation.
12. Thermal energy
13. The heat of vaporization is the amount of thermal energy absorbed when 1 mol of a substance changes from the liquid phase to the vapour phase, without a change in temperature.
14. Students should draw a cooling curve for water, similar to that shown in Figure D2.30 on page 385. The heat of vaporization and the heat of fusion of

water are responsible for the two plateaus on the curve.

15. Students should suggest three of the following factors: insolation, net radiation budget, albedo, cloud cover, atmospheric dust levels, proximity to water, prevailing winds, or the hydrologic cycle.
16. Students should describe two of the following ways by which thermal energy transfer occurs in the biosphere: the action of global winds, the action of ocean currents, or the hydrologic cycle.
17. Tundra, taiga, grassland, and deciduous forest
18. The amount of precipitation is too low to support the growth of trees.
19. Students will suggest one of these plant adaptations: short life cycle, small and close to the ground; and one of these animal adaptations: feed mostly on fish and animals, make protective underground burrow, thick coats and squat bodies.
20. Rain forest, since the climate conditions support the richest population of plants, which can in turn support an equally rich population of animals.
21. Students' diagrams should be similar to the climatographs shown in this section. Both vertical axes and the horizontal axis should be labelled (average temperature, average precipitation, and month, respectively). The climatograph should include a bar graph of monthly precipitation data and a line graph of monthly temperature data. The title of the climatograph should include the name of the location and its latitude.
22. The main factor that determines Earth's biomes is the climate. Students should discuss the relationship between climate and the kinds of life found in a region.

Applications

23. Polar regions have less insolation solar energy due to the angle of incidence of incoming rays and the angle of inclination of Earth. At the poles, incoming radiation has a relatively large angle of incidence, whereas at the equator, the angle of incidence is about 0º. The same quantity of incoming radiation is therefore spread out over a larger area at the poles than at the equator. Earth's angle of inclination causes seasonal differences in the length of daylight with latitude. At the poles, the length of daylight varies from 24 h at the June solstice to 0 h at the December solstice. At the equator, the length of daylight is always about 12 h year-round.
24. Life on Earth requires the natural greenhouse effect to warm Earth. The natural greenhouse effect is caused by absorption by the troposphere of some of the infrared radiation re-emitted from Earth's surface.
25. Naturally occurring greenhouse gases are essential for the survival of all living things on Earth, since they absorb some of the energy re-emitted from Earth's surface, preventing it from escaping back into space. The absorbed energy is converted to thermal energy, which helps to maintain Earth's average temperature in a range that can support life.
26. Convection is transfer of thermal energy through the movement of particles from one location to another. Thermal energy transfer by convection usually occurs in fluids. During convection, the movement of the particles forms a current from one place to another.
27. Warm air rises because it is less dense than cooler air. The particles in warm air have more kinetic energy and move further apart from one another as they absorb more energy. The air becomes less dense and forms an upward convection current.
28. When water changes from solid to liquid phase, absorbed energy is used to make new bonds between the water particles, and so is not converted to kinetic energy. Since temperature increases only when kinetic energy increases, temperature does not change during phase change. This energy is the heat of fusion of the substance.
29. Rearrange the formula for the quantity of thermal energy, Q, to solve for change in temperature, Δt:

$$Q = mc\Delta t$$

$$\text{or, } \Delta t = \frac{Q}{mc}$$

$$= \frac{100\ \text{J}}{(15.0\ \text{g})(0.385\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})}$$

$$= 17.316\,017\ ^\circ\text{C}$$

Calculate the final temperature.

Final temperature = 20.0°C + 17.31602°C
= 37.316 017°C
= 37.3°C

When 100 J of thermal energy is absorbed by 15.0 g of copper at 20.0°C, the final temperature will be 37.3°C.

30. Calculate the quantity of thermal energy, Q, absorbed, using the formula:

$$Q = mc\Delta t$$

$$= (12.5\ \text{g})(0.444\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})(2.5^\circ\text{C})$$

$$= 13.875\ \text{J}$$

$$= 14\ \text{J}$$

When 12.5 g of nickel increases in temperature by 2.5°C, it absorbs 14 J of thermal energy.

31. Calculate the change in temperature, Δt, from the given data:

$\Delta t = 34.0°C - 24.0°C$

$= 10.0°C$

Rearrange the formula for the quantity of thermal energy, Q, to solve for mass, m:

$$Q = mc\Delta t$$

or, $$m = \frac{Q}{c\Delta t}$$

$$= \frac{250\ \cancel{J}}{(0.228\ \frac{\cancel{J}}{g \cdot {}^{\circ}\cancel{C}})(10.0\ {}^{\circ}\cancel{C})}$$

$$= 109.649\,12\ g$$

$$= 110\ g$$

The mass of the piece of tin is 110 g.

32. Calculate the quantity of thermal energy, Q, released, using the formula:

$$Q = mc\Delta t$$

$$= (20.0\ g)(0.388\ \frac{J}{g \cdot {}^{\circ}C})(30\ {}^{\circ}C)$$

$$= 232.8\ J$$

$$= 2.3 \times 10^{2}\ J$$

When a 20.0 g mass of zinc at 30°C cools to 0.0°C, 2.3×10^2 J of thermal energy is released.

33. Calculate the heat of vaporization, H_{vap}, using the formula:

$$H_{vap} = \frac{Q}{n}$$

$$= \frac{305\ kJ}{7.50\ mol}$$

$$= 40.666\,666\ \frac{kJ}{mol}$$

$$= 40.7\ \frac{kJ}{mol}$$

The experimental heat of vaporization of water is 40.7 kJ/mol.

34. Rearrange the formula for the heat of vaporization, H_{vap}, to solve for quantity of thermal energy, Q:

$$H_{vap} = \frac{Q}{n}$$

or, $$Q = H_{vap}n$$

$$= (40.65\ \frac{kJ}{\cancel{mol}})(25.0\ \cancel{mol})$$

$$= 1016.25\ kJ$$

$$= 1.02 \times 10^{3}\ kJ$$

Changing the phase of 25.0 mol of water at 100.0°C from liquid to vapour requires absorption of 1.02×10^3 kJ of thermal energy.

35. Calculate the number of moles, n, using the formula:

$$n = \frac{m}{M}$$

$$= \frac{10\ g}{18.02\ \frac{g}{mol}}$$

$$= 0.554\,938\,9\ mol$$

Rearrange the formula for the heat of fusion, H_{fus}, to solve for quantity of thermal energy, Q:

$$H_{fus} = \frac{Q}{n}$$

or, $$Q = H_{fus}n$$

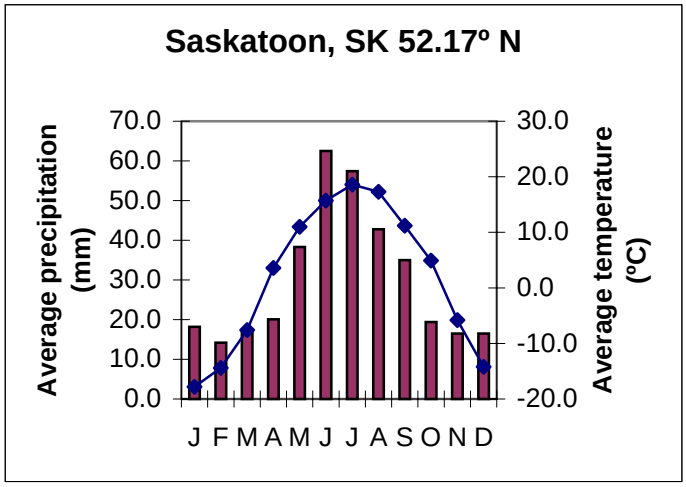
$$= (6.01\ \frac{kJ}{\cancel{mol}})(0.554\,938\,9\ \cancel{mol})$$

$$= 3.335\,182\,7\ kJ$$

$$= 3.34\ kJ$$

Changing the phase of 10.0 g of ice at 0.0°C from solid to liquid requires absorption of 3.34 kJ of thermal energy.

36. a) Students' climatographs should resemble that shown here:



b) Students may predict that Saskatoon is grassland due to the relatively low amounts of rainfall and cool temperatures. Note that Saskatoon is close enough to taiga biomes that it has some characteristics of this biome, and they are reflected in the higher rainfall levels in the summer months. Students should justify their choice based on this factor.

c) Answers will vary. Grasslands are dominated by grasses, and support grazing animals, rodents, and snakes. Taiga is dominated by coniferous trees, and supports carnivorous animals, hunting birds, rodents, and squirrels.

Extensions

37. a) Tundra, since it is covered by snow through much of the year
    b) Tundra would reflect the most, since it has the higher average albedo, and deciduous forest would absorb the most, since it has the lower average albedo.
    c) If students answer yes, they should explain that neither biome would have significant snow cover in July, and hence would have similar albedo. Some may answer no, and explain that tundra will still have snow cover (this would be true if the tundra region were close to either pole).
38. Manchester and Hamburg are at similar latitudes, and so both show similar seasonal changes in average temperature and precipitation. However, Manchester has a warmer climate then Hamburg in the winter months, and has less precipitation in general. These differences in climate are not due to insolation, since insolation varies primarily with latitude. Students should therefore conclude that the differences are due to the moderating effect of ocean currents.

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D3.1 Check and Reflect

1. Global Warming Potential (GWP) is a measure of the ability of a gas to trap thermal energy in the atmosphere. Carbon dioxide is rated 1, and other gases are rated relative to carbon dioxide.
2. Students should give any three of the following gases: carbon dioxide, nitrous oxide (N_2O), methane, halocarbons (CFCs). All of these gases have increased significantly over the last 200 years, with most of the increase occurring in the past 100 years.
3. Students may suggest either analysis of ice-core data or direct measurement of the atmosphere.
4. Nitrous oxide (N_2O) is released by the burning of fossil fuels, and by the use of manure and chemical fertilizers in agriculture.
5. A carbon sink is any process that removes carbon dioxide from the atmosphere. Examples include photosynthesis by plants and solution of carbon dioxide in large bodies of water.
6. The enhanced greenhouse effect is the change in Earth's net radiation budget caused by the increase in human-generated greenhouse gases.
7. Answers may vary. Examples of evidence for climate change during the 20th century include: the average temperature on Earth increased by 0.6°C, the area of Earth covered by ice and snow decreased, sea levels worldwide rose, and the temperature of the oceans increased.
8. By sending work out to other scientists to evaluate, the IPCC can be sure that any errors, omissions, or controversial conclusions are considered in the evaluation of the work. That is, other scientists offer unbiased expert review.
9. Natural greenhouse gases are those gases in the atmosphere that help to keep Earth's temperature in a range that supports life. Many of these are the same gases as human-generated greenhouse gases (e.g., carbon dioxide), but the levels of human-generated gases are not balanced.
10. Since the Industrial revolution, humans have increasingly burned fossil fuels and deforested many regions. As a result, the balance between carbon sinks and carbon sources has changed, so that atmospheric carbon dioxide levels have increased. Agriculture has also contributed, by the emission of large amounts of methane and some nitrous oxide. Other human practices include the development and use of halocarbons.
11. Photosynthesis is the process by which plants take up carbon dioxide and convert it to food. Plants therefore remove carbon dioxide, a greenhouse gas, from the atmosphere.
12. Answers will vary. Students' diagrams should communicate that the natural greenhouse effect maintains Earth's temperature in a range that supports life, whereas the enhanced greenhouse effect causes Earth's temperature to increase. The natural greenhouse effect has a balance between carbon sinks and carbon sources, whereas the enhanced greenhouse effect has more carbon sources than carbon sinks.
13. Students are expected to show that they understand that science does not depend on fact, but on interpretation of data. Students should explain that data may be interpreted in more than one way, and new data often change those interpretations.
14. Answers will vary depending on your region. Students' answers should refer to common activities that decrease carbon sinks (e.g., removing trees) and that are carbon sources (e.g., burning of fossil fuels). At the time of writing, most students are likely to conclude that over the next 20 years, there will be more carbon sources and fewer carbon sinks.
15. Students' views should be supported by evidence discussed and collected in this lesson.

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D3.2 Check and Reflect

1. The GCM climate model is a computer model that incorporates the laws of physics to model climate on a global scale.
2. Climate change affects the whole biosphere and thus requires collaboration of all countries.
3. The Montreal Protocol is an international agreement signed by 182 countries to phase out the use of CFCs.
4. CFCs are a type of halocarbon, which are human-made chemicals that can absorb significant amounts of thermal energy. These chemicals were used to replace flammable and toxic compounds used in aerosol cans, fire extinguishers, and air conditioners.
5. The United Nations Framework Convention of Climate Change was important because it set out a framework and process for future international agreements.
6. The Kyoto Protocol is an international agreement for nations to reduce the emission of greenhouse gases to the atmosphere.
7. Emission-reduction credits are a credit given to countries for their actions that contribute to a reduction in global greenhouse gas emissions. For example, Canada could receive credits for helping a developing country to reduce its emissions, or for planting more trees.
8. Answers will vary but are likely to include suggestions such as taking public transport or riding a bicycle instead of using the family car.
9. Carbon dioxide sequestering involves removal of carbon dioxide gas from the atmosphere. Students may cite the example of injecting carbon dioxide gas into the ground to extract oil from existing reserves.
10. Political and economic issues would still have to be solved to implement a successful solution to climate change.
11. Sometimes scientists want to look at a particular effect rather than the whole general climate model. Simpler models allow for this. Simpler models also do not require access to expensive equipment, and so may be used when costs are an issue.
12. Examples may vary, but should reflect students' understanding of the links between human activity and greenhouse gas emissions. For example, a possible answer is that Canadian industry could use wood waste instead of fossil fuels for heating.
13. Answers will vary, and could reflect current events rather than information provided in the student text. Possible examples include that some countries (or provinces) are concerned that implementing the Kyoto Protocol could negatively effect their economies, and that some developing nations see implementation of the Kyoto Protocol as a barrier to economic development.
14. A diverse group like the IPCC shows that the issue of climate change is not being "driven" by one country, one political ideology, or one economic point of view.
15. Students' answers should relate that climate change could affect all humans and all nations. The social, political and environmental issues for all countries must be considered when finding a solution to climate change to ensure that everyone shares the costs and benefits of any changes.

Student Book page 430

D3.3 Check and Reflect

1. Answers will vary. Three consequences of climate change include: increase in extreme weather; health consequences for many people; and shifting of biomes.
2. Tundra biomes would be impacted more severely because the snow, ice and permafrost would melt, causing significant changes in the biome. This would also decrease the albedo of tundra biomes, so the rate of temperature change would be higher than in other biomes.
3. Climate change would change the net radiation budget for biomes. The result would be a different climate in the region of a biome, causing some living things to die or leave the area and other living things to grow or enter the area.
4. Potential consequences for the agriculture industry in Alberta include longer growing seasons, more droughts, increases in crop yields, and increases in pests.
5. Potential consequences on forests in Alberta include trees being severely stressed, trees being able to grow further north, and an increase in pests.
6. The sectors targeted for greenhouse gas reduction are transportation, energy, building, agriculture and forestry, and industry.
7. The transportation sector could develop more fuel-efficient vehicles, use fuels that produce less carbon dioxide, such as ethanol, develop technologies that reduce or eliminate emissions, such as hydrogen-powered fuel cells, encourage efficiencies in freight transport, and encourage more use of public transit.
8. Agriculture and forestry in Canada could benefit from climate change because growing seasons would be extended. This would allow for greater

production of crops and harvests, and more variety in the crops and trees that could be grown.
9. Answers may vary, but students could use a bar graph to illustrate the data in Figure D3.26.
10. Students' answers will vary, but could include taking public transportation, planting new trees, or investing in new energy-efficient technologies.
11. The conclusions from each computer modelling system can vary because they are based on different assumptions and data.
12. Students' answers will vary, but one possible answer is that a change in climate could reduce the number of skiing days per year in the Rockies.
13. Students' answers should summarize the current status of Canada's implementation of the Kyoto Protocol. This answer will change yearly.
14. Answers will vary. This question could be assigned to students who finish their work early, or as an enrichment activity.
15. Answers will vary. This question could be assigned for students who finish their work early, or as enrichment.

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D3.0 Section Review

Knowledge

1. The IPCC assesses the impact of human activity on climate by summarizing the research of over 2500 scientists. Its findings are published in reports.
2. Some human activities that add greenhouse gases to the atmosphere include: fossil fuel use, industrial processes, agriculture, and electricity generation, particularly from coal.
3. The data show that the concentration of greenhouse gases has increased significantly since the 20th century, and continues to increase.
4. 0.6ºC
5. The IPCC have reported scientific studies that show the average temperature of Earth's surface has increased; the IPCC regards this as an indicator of climate change.
6. Students are likely to report two of the following as evidence against climate change: areas of the Antarctic have not shown any increase in average temperature, loss of ice cover, or an increase in extreme weather.
7. Global warming refers to the observed increase in Earth's average temperature.
8. Over the last century, there has been a loss of carbon sinks (which remove carbon dioxide from the atmosphere) through clearing of forest cover. There has also been an increase in carbon sources (which contribute carbon dioxide to the atmosphere) through changes in human activity, particularly in the burning of fossil fuels. As a result, the balance between carbon sinks and carbon sources has changed in favour of carbon sources, so that there is a net increase in emissions of carbon dioxide gas to the atmosphere.
9. Answers may vary. Possible examples include that carbon dioxide may be removed from the atmosphere by plants, through photosynthesis, or by technologies such as carbon dioxide sequestering.
10. The enhanced greenhouse effect refers to the increase in concentrations of greenhouse gases in the atmosphere. Since these gases trap thermal energy, this increase is believed to be primarily responsible for global warming.
11. Nations that signed the Montreal Protocol agreed to phase out the use of CFCs.
12. CFCs react with ozone in the troposphere and convert the ozone to oxygen, which has caused a thinning of Earth's ozone layer. As a result, more ultraviolet radiation reaching Earth's surface could contribute to an increase in global average temperature. Thinning of the ozone layer could also increase the rates of cancers caused by exposure to ultraviolet light.
13. The UNFCCC was the agreement on a framework that sets out a process for future agreements on climate change. This framework included the concept of sustainable development, in which the world's resources must be used in ways that maintain the resources for future generations.
14. Canada will have to reduce its greenhouse gas emissions by 6% to reach 1990 levels.
15. Five areas targeted by Canada for greenhouse gas reduction are transportation, energy, buildings, agriculture and forestry, and industry.
16. Use of renewable energy sources would decrease the use of fossil fuels, which are one of the main sources of greenhouse gases. Many renewable energy sources, such as solar energy or wind-generated electricity, do not emit any greenhouse gases.
17. Possible impacts in Alberta due to climate change include shifting of existing biomes, increased frequency of drought, increased crop yields, warmer temperatures, wetland animals potentially facing extinction, and increased health problems, such as asthma.
18. Answers will vary, but could include some of the following points. Alberta's forests would be severely stressed by rapid climate change and pest populations would increase, but trees could grow

further north. Social impacts include jobs in forestry disappearing in some areas, and being created in other areas. Environmentally, local ecosystems may change due to trees dying or new trees growing. Economically, the forest industry could be negatively impacted by the loss of trees, but this may be offset by growth of new trees.

Applications

19. Students' summaries should identify impacts discussed in the text. You may wish to remind students that questions 17 and 18 focused on Alberta but this question focuses on global impacts, such as melting snow and ice in the polar regions, increased extreme weather, and warmer oceans impacting on fish and other living resources.

20. The level of confidence associated with data gives the reader an appreciation of how confident scientists are of the predictions they have made based on their data.
21. Sustainable development is a global issue because its goal is to use the world's resources in ways that maintain them for future generations, and not for the economic or social benefit of just one nation.
22. The key international agreements dealing with issues of global climate change are the Montreal Protocol, an agreement on banning CFCs; The United Nations Framework Convention on Climate Change, which provided guidelines for future agreements; and the Kyoto Protocol, an agreement to reduce emissions of greenhouse gases.
23. Emission-reduction credits can be gained in three ways: a developed country helping a developing country to reduce its emissions; a developed country helping another developed country when there is an economic problem of a temporary nature; a country engages in a process to remove carbon dioxide from the atmosphere, such as planting a forest.
24. Buildings contribute to greenhouse gases at the time of construction and through the energy systems used. Reduction in greenhouse gases can occur by upgrading energy systems to use more energy-efficient heating and cooling systems and household appliances.
25. Human health could be negatively affected by increased illness due to heat waves, or by new diseases being able to survive in warmer weather.

Extensions

26. The study of climate is complex. To date no model can predict climate change perfectly every time. Lack of data, particularly on past climate events, plays a role in this inaccuracy.
27. Students are expected to show understanding of the long-term consequences of climate change for the biosphere as a whole, and to appreciate that these may go beyond their own direct experience in their lifetime.
28. Concept maps should include all bold-faced terms with "climate change" as the starting point.

Student Book pages 435–439

Unit D Review

Vocabulary

1. Students' concept maps should convey their understanding of the definitions provided in the text and concepts developed in the activities completed during the unit.

Knowledge

D1.0

2. Weather is daily conditions like humidity, air pressure, and cloud cover. Climate is the average weather conditions over a longer period of time, usually a minimum of 30 years.
3. Answers will vary. A sample answer could be as follows: A desert climate is hot and dry most of the time. However, the weather in a desert will vary from day to day. Some days may be cloudy and cooler, and some may be sunnier and hotter than the average conditions.
4. Earth's atmosphere has a higher concentration of nitrogen and oxygen and a trace amount of methane. Mars and Venus have a higher concentration of carbon dioxide and no methane. All three atmospheres have trace amounts of argon.
5. The four layers of Earth's atmosphere are the thermosphere, mesosphere, stratosphere, and troposphere.
6. In the troposphere and mesosphere, the temperature decreases with altitude. In the stratosphere and thermosphere, the temperature increases with altitude.
7. The ozone layer is a region in the stratosphere that contains high concentrations of ozone gas.

8. Students' diagrams should be similar to Figure D1.6 on page 346.
9. The hydrosphere consists of all the water on Earth, whether present as ice, liquid water, or water vapour, and all the organisms that it contains. About 97% is salt water and 3% is fresh water. The amount of water on Earth always remains the same, and the hydrosphere is warmed mainly by incoming sunlight.
10. Students' answers will vary, but should reflect situations where climate affects students' personal lives, such as the types of clothes to wear at certain times of the year, or the types of homes that are needed.
11. Students' answers will vary, but should show how climate is related to the adaptations of the chosen animal to its environment.
12. Anecdotal and scientific

D2.0

13. The main source of energy for Earth is solar energy.
14. The different types of radiation found in solar radiation are those making up the electromagnetic spectrum. Refer to Figure D2.2 on page 357.
15. Radiant energy is energy transmitted as electromagnetic waves.
16. Insolation is the amount of solar energy received by a region on Earth's surface.
17. Earth's angle of inclination determines the seasons. Due to the tilt of Earth, the hemispheres receive different amounts of insolation over the course of a year.
18. The angle of inclination of the Earth is 23.5^{o}.
19. Both reflection and absorption of solar energy can decrease the amount of solar energy that reaches Earth's surface. Reflection sends the solar energy back into space, whereas absorption contributes to the natural greenhouse effect, which maintains Earth's average temperature in a range that supports life.
20. Photosynthesis.
21. Insolation decreases with increases in latitude.
22. The albedo of water is greater than that of grasslands.
23. A city at the equator has more insolation than Red Deer because the angle of incidence of incoming radiation is greater at Red Deer, and the length of daylight varies more at Red Deer than at the equator.
24. Water vapour.
25. Three greenhouse gases are carbon dioxide, methane, and nitrous oxide.
26. The net radiation budget is the main factor that determines the climate of any region on Earth. The net radiation budget varies with latitude; regions at higher latitudes tend to have net radiation budget deficits, whereas regions at lower latitudes tend to have net radiation budget surpluses. This variation is further modified by the effects of albedo, cloud cover, and atmospheric dust.
27. Regions of Earth's surface at or near the equator (latitude 0°) have a net radiation budget surplus.
28. Convection
29. Thermal energy
30. From a straight-line path from the poles to the equator, wind is deflected rightward in the Northern Hemisphere and leftward in the Southern Hemisphere, relative to a person standing facing the equator at the respective pole.
31. The Coriolis effect is the deflection of objects, including global winds, from a straight-line path due to Earth's rotation. The jet stream is a rapidly flowing band of air in the stratosphere.
32. Convection is thermal energy transfer through the movement of particles. During convection, particles absorb energy and move apart, and so the density of the substance decreases. The less-dense substance will then begin to rise. Air pressure is the pressure exerted by a mass of air above any point on Earth's surface. Since it is less dense, warm air exerts less pressure than cold air.
33. Differences in insolation create different net radiation budgets. Wind moves the energy from areas of net radiation budget surplus (equatorial regions) to areas of net radiation budget deficit (polar regions).
34. To determine the specific heat capacity of a substance, the mass of the substance, the temperature change, and the amount of thermal energy added must be controlled.
35. A calorimeter is any device used to determine the transfer of thermal energy.
36. Thermal energy is transferred in the hydrologic cycle through the absorption and release of thermal energy that take place when water changes phase, and through the action of ocean currents.
37. The heat of fusion is the amount of thermal energy released when 1 mol of a substance changes from liquid phase to solid phase, without a change in temperature. The heat of vaporization is the amount of thermal energy absorbed when 1 mol of a substance changes from liquid phase to vapour phase, without a change in temperature.
38. Evaporation of water requires absorption of thermal energy. This energy is taken from the surroundings and released when the water vapour condenses.

39. The biosphere is composed of all the living things on Earth and the physical environment that supports them. A biome is a large geographical region with a particular range of temperature and precipitation levels, and the plants and animals that are adapted to those climate conditions. The biosphere contains many biomes.
40. Answers will vary. Biomes found in Canada are: tundra, characterized by cold temperatures, much snow, and lichens: taiga, characterized by temperatures warmer than tundra, long winters and short summers, and coniferous trees; deciduous forest, which have even milder temperatures, distinct winters and summers, and deciduous trees; and grassland, characterized by a dry, cool climate and grasses.
41. Most energy enters a biome from the Sun.
42. Answers will vary. Matter could enter and leave a biome by way of a river or by an animal migrating.
43. The biomes found in western Canada are tundra, taiga, and grassland.
44. A climatograph provides a graphical representation of a region's average temperature and precipitation.
45. A climatograph includes data for monthly average precipitation and average temperature for a specific region.
46. Climatographs can help one to decide which factors are most likely to be responsible for the climate of a region. The main factor is the latitude of the region. If the climate differs from that of other regions at that latitude, then other factors involved in thermal energy transfer are assessed, such as altitude, global winds, and ocean currents.

D3.0

47. General circulation models consider the atmosphere, lithosphere, and hydrosphere.
48. Intergovernmental Panel on Climate Change
49. The natural greenhouse effect is the absorption of emitted energy by greenhouse gases that occur naturally in the atmosphere. Global warming is the observed increase in the average global temperature.
50. These greenhouse gases are thought to affect Earth's climate more today because the levels of these gases is increasing significantly.
51. Burning fossil fuels contributes the highest level of greenhouse gas emissions.
52. The enhanced greenhouse effect is the change in Earth's net radiation budget caused by the greenhouse gases emitted by human activities.
53. Carbon sinks remove carbon dioxide gas from the atmosphere. Carbon dioxide is a greenhouse gas and its emissions have increased substantially over the past century, so carbon sinks act to reduce the levels of this gas, and therefore the enhanced greenhouse effect.
54. Answers will vary, but may include suggestions such as the increase in the surface temperature of Earth, loss of polar ice cover, increase of the average temperature of the world's oceans, increase in the level of the world's oceans, loss of fish stocks.
55. Confidence levels for data and predictions provide a context for interpreting the data or predictions.
56. Students' timelines should reflect the key agreements discussed in the text (Montreal 1987, UNFCCC 1992, and Kyoto 1998.)
57. The Montreal protocol set out a process for phasing out CFCs.
58. Kyoto emission-reduction credits involve rewarding countries for activities related to reducing global greenhouse emissions.
59. This study was the first assessment of the social, biological, and economic impacts of climate change on Canada.
60. Answers could include negative or positive consequences of climate change. Negative consequences include loss of species in tundra biomes, increased prevalence of drought, and damage to human health due to increase in pollution and heat. Positive consequences include increases in crop production in northern areas, increased forest cover in northern areas (benefiting the forestry industry), and warmer temperatures.
61. Students' paragraphs should indicate that an increase in the average global temperature would likely decrease the albedo of the Arctic, since the amount of snow and ice cover would decline.
62. Students should discuss the actions proposed for all five sectors Canada has targeted for reduction in greenhouse-gas emissions: transportation, energy, buildings, agriculture and forestry, and industry.
63. Answers will vary, and could include changes such as using dishwashers less, using buses or bicycles more, and using air-conditioning less.

Applications

64. a) The last two weeks of rain have made for miserable weather.
    b) This kind of climate is the reason good crops grow here every year.
65. Students' answers will vary, but should reflect their personal experience, such as how one coped with rain on a camping trip.
66. Students' answers will vary, but should reflect their personal experiences, such as the installation of air conditioning in a home.

67. Anecdotal evidence could include discussions with people living in the region or reports of changes in animal behaviour observed by people. Scientific evidence could include carbon dioxide concentrations in ice-core samples or changes in the thickness of tree rings.
68. Students' maps should show the connections between the listed words.
69. Answers will include some of the following points: the troposphere is where most weather occurs, the only layer with enough oxygen to support life, temperature decreases with altitude: the stratosphere is where the ozone layer occurs, temperature increases with altitude; the mesosphere is where temperature ranges from 0^{o}C to -100^{o}C; the thermosphere is where temperature ranges from -100^{o}C to $+1500^{o}$C.
70. Large amounts of dust in the atmosphere could reflect more radiation back into space and change Earth's net radiation budget.
71. Answers will vary. One possible answer is that large bodies of water (the hydrosphere) can moderate climate near land (the lithosphere).
72. The division of Earth into different biomes makes it easier to study and understand the interactions of the organism within a biome and between biomes, as well as to link these to climate.
73. Students' answers should give specific examples of the following events. Changes in the borders of a biome would mean a change in the precipitation, average temperature, and the dominant plant and animal life. The climate change might make the environment an unsuitable habitat for some living things. Humans may be affected in what they could grow, what clothing or shelter they needed, and what kinds of activities they could do.
74. A system is a set of interconnected parts, and the surroundings are everything outside the system.
75. Answers may vary. An example of a closed system is the hydrologic cycle. Matter (water) is not exchanged with the surroundings, but energy from the Sun is. In an open system, such as a biome, both energy and matter are exchanged with the surroundings.
76. Cells and biomes are open systems in that they exchange matter and energy with their surroundings.
77. If the input energy was reduced, a biome might experience a cooling trend.
78. Variations in insolation are a major factor in determining climate, which in turn determines the type of plants and animals that can survive in a region. Variation in insolation therefore is also a main factor in determining the locations of Earth's biomes.
79. Answers will vary, but students should discuss the fact that the angle of inclination of Earth causes all cities in Canada to experience seasonal changes, with colder weather from September to March, and differences in length of daylight. The angle of incidence causes all Canadian cities to have less intense radiation than areas closer to the equator, so our temperatures are also cooler year round.
80. Canada has a higher average albedo in the winter, since most regions will be covered with snow.
81. The natural greenhouse effect is the absorption of energy by gases in the atmosphere, which helps to keep Earth's average temperature in a range that will support life.
82. Convection is thermal energy transfer by movement of particles. In a fluid, absorption of energy causes the particles to gain kinetic energy and move apart. As they move apart, the substance becomes less dense.
83. Wind and ocean currents transfer thermal energy from regions of net radiation budget surplus (equatorial regions) to regions of net radiation deficit (polar regions). Students may also answer that thermal energy transfer may occur by either convection or conduction, but they should include examples.
84. Students diagrams should be similar to Figure D2.16 on page 368.
85. Calculate the change in temperature, Δt, from the given data:

    $\Delta t = 20.0°\text{C} - 10.0°\text{C}$

    $= 10.0°\text{C}$

    The mass, m, of water is 100.0 kg, or 100 000 g.

    Calculate the quantity of thermal energy, Q, from the formula:

    $Q = mc\Delta t$

    $= (100\ 000\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}})(10.0^{\circ}\text{C})$

    $= 4\ 190\ 000\ \text{J}$

    $= 4.19 \times 10^{6}\ \text{J}$

    $= 4.19 \times 10^{3}\ \text{kJ}$

    To increase the temperature of 100.0 kg of water from 10.0°C to 20.0°C requires 4.19×10^{3} kJ of thermal energy.
86. Rearrange the formula for quantity of thermal energy, Q, to solve for change in temperature, Δt:

    $Q = mc\Delta t$

    or, $\Delta t = \frac{Q}{mc}$

    $= \frac{1290\ \text{J}}{(12.0\ \text{g})(4.19\ \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}})}$

    $= 25.656\,324^{\circ}\text{C}$

    $= 25.7^{\circ}\text{C}$

When 1290 J of thermal energy are added to 12.0 g of water and no phase change occurs, the temperature changes by 25.7°C.

87. Calculate the change in temperature, Δt, from the given data:

$\Delta t = 46.0°C - 24.0°C$
$= 22.0°C$

Rearrange the formula for quantity of thermal energy, Q, to solve for mass, m:

$$Q = mc\Delta t$$
$$\text{or, } m = \frac{Q}{c\Delta t}$$
$$= \frac{148.5\ \text{J}}{(0.449\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}})(22.0^\circ\text{C})}$$
$$= 15.033\,407\ \text{g}$$
$$= 15.0\ \text{g}$$

The mass of the piece of iron is 15.0 g.

88. Rearrange the formula for quantity of thermal energy, Q, to solve for specific heat capacity, c:

$$Q = mc\Delta t$$
$$\text{or, } c = \frac{Q}{m\Delta t}$$
$$= \frac{10.0\ \text{J}}{(15.0\ \text{g})(5.1^\circ\text{C})}$$
$$= 0.130\,718\,9\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$$
$$= 0.13\ \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$$

The experimental specific heat capacity of gold is 0.13 J/g·°C.

89. Calculate the number of moles, n, from the given data using the formula

$$n = \frac{m}{M}$$
$$= \frac{200\ \text{g}}{18.02\ \frac{\text{g}}{\text{mol}}}$$
$$= 11.098\,779\ \text{mol}$$

Rearrange the formula for heat of fusion, H_{fus}, to solve for quantity of thermal energy, Q:

$$H_{fus} = \frac{Q}{n}$$
$$\text{or, } Q = H_{fus}n$$
$$= (6.01\ \frac{\text{kJ}}{\cancel{\text{mol}}})(11.098\,779\ \cancel{\text{mol}})$$
$$= 66.703661\ \text{kJ}$$
$$= 66.7\ \text{kJ}$$

It takes 66.7 kJ of thermal energy to melt 200 g of ice at 0.0°C.

90. Rearrange the formula for heat of vaporization, H_{vap}, to solve for quantity of thermal energy, Q:

$$H_{vap} = \frac{Q}{n}$$
$$\text{or, } Q = H_{vap}n$$
$$= (40.65\ \frac{\text{kJ}}{\cancel{\text{mol}}})(2.00\ \cancel{\text{mol}})$$
$$= 81.3\ \text{kJ}$$

It takes 81.3 kJ of thermal energy to evaporate 2.00 mol of liquid water at 100.0°C.

91. Rearrange the formula for heat of vaporization, H_{vap}, to solve for the number of moles, n:

$$H_{vap} = \frac{Q}{n}$$
$$\text{or, } n = \frac{Q}{H_{vap}}$$
$$= \frac{203\ \cancel{\text{kJ}}}{40.65\ \frac{\cancel{\text{kJ}}}{\text{mol}}}$$
$$= 4.993\,899\ \text{mol}$$
$$= 4.99\ \text{mol}$$

When 203 kJ of thermal energy are added to liquid water at 100.0°C, 4.99 mol enter the vapour phase.

92. Rearrange the formula for heat of fusion, H_{fus}, to solve for the number of moles, n:

$$H_{fus} = \frac{Q}{n}$$
$$\text{or, } n = \frac{Q}{H_{fus}}$$
$$= \frac{21\ \cancel{\text{kJ}}}{6.01\ \frac{\cancel{\text{kJ}}}{\text{mol}}}$$
$$= 3.494\,176\,3\ \text{mol}$$

Then, convert the number of moles, n, to mass, m:

$$n = \frac{m}{M}$$
$$\text{or, } m = nM$$
$$= (3.494\,176\,3\ \cancel{\text{mol}})(18.02\ \frac{\text{g}}{\cancel{\text{mol}}})$$
$$= 62.965056\ \text{g}$$
$$= 63\ \text{g}$$

If 21 kJ of thermal energy are added to ice at 0.0°C, 63 g will enter the liquid phase.

93. Greenhouse gases increased in the 20th century as follows: carbon dioxide, approximately 290 ppm to 320 ppm; nitrous oxide, approximately 0.280 ppm to 0.315 ppm; and methane, approximately 0.900 ppm to 1.750 ppm.

94. Students' answers will vary, but should show an understanding of the global nature of climate change.

95. Students' answers will vary, but could include the cost in terms of harming present economies or lack of resources to purchase technology to

reduce greenhouse emissions. Social factors could include unwillingness by humans to change their present behaviour in order to reduce greenhouse gas emissions.

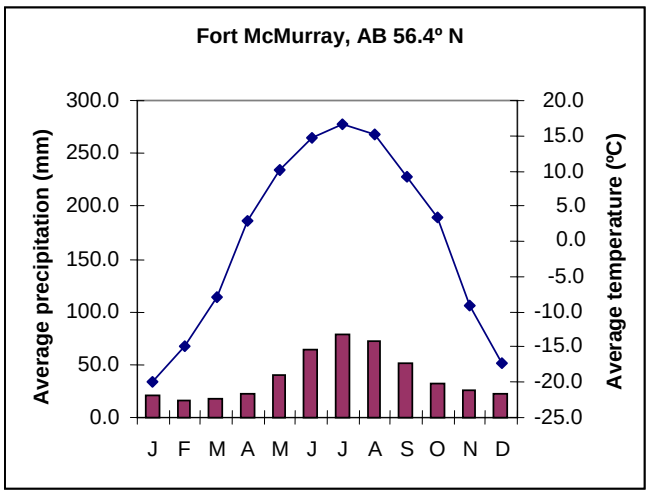
96. Students' suggestions will vary. Possible effects include impacts on the agriculture industry, such as longer growing seasons, greater number of pests, and an increase of extreme weather, such as drought. Possible impacts on the forestry industry include extension of the range of some tree species farther north, slower growth due to lower precipitation levels, emergence of new forest pests, and increased numbers of forest fires. Natural ecosystems are impacted as species move or die. Human health is impacted as heat waves increase air pollution with further impact on people with respiratory illnesses, such as asthma.

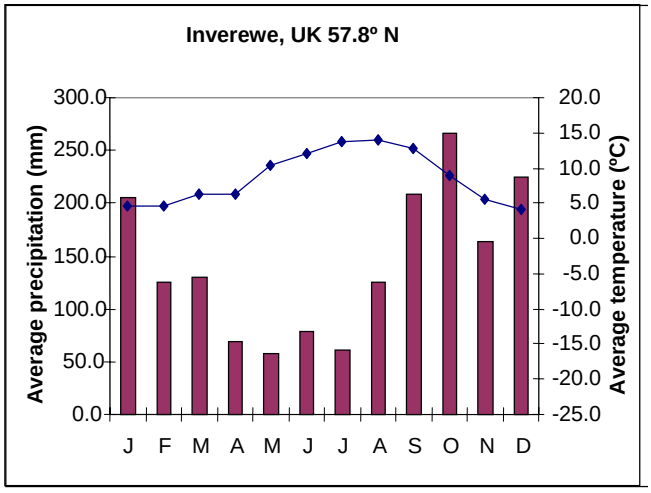
Extensions

97. Some people point out that we have insufficient knowledge of long-term cycles of climate change and of the interactions between the components of the biosphere to be able to predict whether climate change is occurring or will occur in the future.
98. Answers will vary. A likely hypothesis is: The growing season is getting longer because the average temperature is increasing. This could be investigated by comparing the average temperature each month over the past 30 years to the average temperature each month over the past 100 years, using weather and climate data.
99. A biome is considered to be an open system because energy and matter are inputs into the system (the biome) from the surroundings, and also outputs to surroundings.
100. Where ozone is depleted, increased levels of ultraviolet radiation will result.
101. Increased dust in the atmosphere can cause more of the incoming solar energy to be reflected back into space, which would decrease the net radiation budget. Increased atmospheric dust can also cause more absorption of the thermal energy re-emitted from Earth's surface, which would increase the net radiation budget.
102. A mass of cold air will be denser and consequently have a higher pressure than the warm summer air over the town. As a result, the wind will blow from the west to the east as pressure equalizes.
103. If water had a low heat capacity, the effects of large bodies of water on local weather and climate would not be as noticeable. The hydrologic cycle would also occur much more rapidly as it would take less energy to evaporate water.
104. IPCC assessments are based on the work of international collaboration between scientists. The process of peer review of the data ensures the consensus is a fair, unbiased, and accurate reflection of the data.
105. Reporting confidence estimates tells the public how reliable the data are in terms of evidence for climate change. A disadvantage is that an important piece of information could be given a lower confidence estimate, and receive less attention than it merits.
106. Students' answers will vary, but should draw upon the issues discussed in this unit. The answer to this question is complicated, but students should be able to write an introductory statement, with supporting evidence in the form of three paragraphs, one for each area—political, social and environment—and a concluding paragraph.

Skills Practice

107. Students' answers will vary, but should include and interpret information on the weather in Caracas during the year, and suggest the best times to travel and why. Most students will note that from June to January, Caracas experiences high amounts of rainfall, and so will suggest that travel be restricted to the driest months of February to March. Raingear should be included in clothing suggestions. All students' suggestions should be clearly linked to the data in the climatograph.
108. Students should construct both climatographs with the same scales for precipitation and temperature in order to compare the climates. Climatographs will similar to those given here:





Students should note that Inverewe is warmer and has much more precipitation than does Fort McMurray. The proximity of Inverewe to warm ocean currents is the main factor in the mild wet climate experienced in this city.

Self Assessment

109. – 112. Students' answers will vary, but should reflect the topics they have discussed and what they have learned in this unit. These questions provide an opportunity for you to look for evidence of attitudinal growth. Attitude outcomes can be found in the Program of Studies.