CHAPTER 10 REVIEW ANSWERS

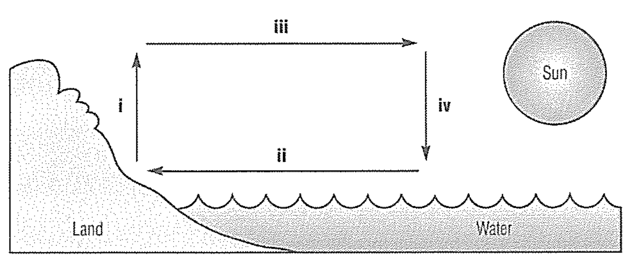
Student Book Pages 398–3993

Understanding Key Concepts

1. (a) A pot of potatoes boiling on the stove is an open system: energy in the form of heat can cross the system's boundaries (the pot itself), and matter (water/steam and potatoes) can also be moved across the system's boundaries.
   (b) A chemical reaction taking place inside a sealed vessel could be considered a closed system. Energy (heat) can enter or leave the system but matter cannot.
   (c) A bird sitting in a birdhouse is an open system, since the bird (matter) can come in and out of the house, bringing along food and nesting material (also matter). Thus energy stored in the chemical bonds in the bird's food—and in the bird—also moves in and out of the house. Also, the heat of the bird's body (energy) is not contained by the birdhouse.
   (d) Hot soup inside a thermos jug—at least a good one—could be considered an isolated system: neither the soup (matter) nor its thermal energy can get in or out of the thermos.
   (e) The coffee grounds inside an unopened coffee can is a closed system, since, although the coffee grounds (matter) cannot pass through the walls of the container, energy can. For example, if the can was left in the Sun, the can would warm up, and so would the coffee grounds.
   (f) Earth is a closed system. Only in rare circumstances does matter cross Earth's boundaries, however, energy crosses its boundaries in the form of solar radiation.
2. The biosphere is the location on Earth where living things are found. This includes some parts of the lithosphere, hydrosphere, and atmosphere.
3. Radiant energy from the Sun interacts with the atmosphere by being partially absorbed, reflected, or scattered by components in the atmosphere, such as water vapour and aerosols. Some sunlight is also reflected by the lithosphere (e.g. a desert) and hydrosphere (e.g. the ocean). The lithosphere and hydrosphere also absorb sunlight, which warms them.
4. Some of the energy that Earth radiates back into the atmosphere is trapped by greenhouse gases. These gases radiate the energy in all directions, including back to Earth. You could say that the energy is used as it passes through Earth's systems.
5. It is important for Earth's radiation budget to be balanced because if Earth lost too much radiation, for example, if there were no greenhouse gases, Earth would be too cold to support life as we know it. If, however, Earth did not lose enough radiation, it would become too hot to support life as we know it, or perhaps any life at all.
6. Three things that happen to sunlight that prevent some of it from being absorbed by Earth's surface are: (a) sunlight being reflected by water vapour and aerosols in the atmosphere; (b) sunlight being absorbed by water vapour and aerosols in the atmosphere; and (c) sunlight being reflected from Earth's surface.
7. If there were no greenhouse gases in the atmosphere, the infrared radiation given off by Earth would radiate out into space, instead of being radiated back to the lower atmosphere. As a result, Earth's average global temperature would drop to −19°C.
8. The seasons change because Earth turns on a tilted axis. Thus, in December the North Pole faces away from the Sun. Since the northern hemisphere receives less sunlight at this time of year, it is cold and the days are short. The opposite is true in the southern hemisphere. In June, the North Pole tilts toward the Sun. This creates summer conditions in the northern hemisphere, with warmer temperatures, and long days. Again, the opposite is true in the southern hemisphere.
9. The reason the seasons are the opposite in the northern and southern hemispheres is that when the northern hemisphere is tilted toward the Sun, the southern hemisphere is tilted away from the Sun. The reverse is also true.
10. Polar zones: have 24 h of daylight and 24 h of darkness at some time during the year. Temperate zones: never have 24 h of darkness or daylight and never have solar rays entering perpendicular to the surface. Tropical zone: Solar rays are perpendicular at some time during the year.
11. The quantity that describes the amount of thermal energy required to raise the temperature of a substance by 1.0°C is the substance's specific heat capacity.

12. The reason energy from the Sun can warm the air is that it does so indirectly: The solar energy that is absorbed by the lithosphere and hydrosphere is eventually radiated back to the atmosphere as infrared radiation, which heats the air.
13. Conduction is a mechanism in which energetic molecules collide with other molecules, thereby transferring some of their energy. The ground and water, heated by solar radiation, transfer thermal energy to the atmosphere when energetic molecules from Earth's surface collide with air molecules. Convection occurs when air circulates and distributes the heat: Warm air expands and rises, eventually cools, and drops, which creates air currents.
14. Energy is transferred when a substance goes through a phase change: a melting solid absorbs heat; a freezing liquid releases heat; an evaporating liquid absorbs heat; and a condensing liquid releases heat. The heat required or given off during these phase changes are called the heat of fusion and the heat of vaporization. A substance that is going through a phase change will therefore absorb or release energy without changing temperature during the phase change.
15. The hydrologic cycle involves the processes of transpiration (evaporation from the trees), evaporation from the land and oceans, condensation in the atmosphere, precipitation to the oceans and land masses, and run-off from the land masses to the oceans.
16. With enough heat energy (the heat of vaporization) and other conditions, liquid water in oceans, lakes, rivers, soil, and plants, will evaporate. The water vapour will rise, and when the air becomes oversaturated or if the air cools sufficiently (loses the heat of vaporization to the surroundings), the water vapour will condense, and fall as precipitation. Also, when snow and ice melt, they absorb heat (heat of fusion) from the surroundings; when liquid water freezes it releases heat energy.
17. The Coriolis effect leads to a pattern in ocean currents as it does with air currents. The currents bend to the right in the northern hemisphere and to the left in the southern hemisphere. Water currents are also affected by the presence of continents, which results in more of a circular pattern of flow than found with air currents.
18. (a) Both climate and weather are descriptions involving temperature and precipitation data. However, weather changes day to day whereas climate is a long-term average of weather.
    (b) The Gulf Stream and North Atlantic Drift are both warm ocean currents. The Gulf Stream is warmer and moves up the eastern United States, and crosses the Atlantic. The North Atlantic Drift is a continuation of the Gulf Stream that goes to the United Kingdom and Scandinavia.
    (c) El Niño and La Niña are both phenomena observed by a shifting in the ocean's currents. El Niño describes the effect on South America when the ocean is warmer and rains come. La Niña is the opposite. The west coast of South America is colder and drier than normal.
    (d) Heat of fusion and heat of vaporization are both quantities of energy associated with phase changes; fusion is that required to melt while vaporization is that required to evaporate.
    (e) Both the greenhouse effect and greenhouses involve the warming of the air. In a greenhouse, the glass prevents the warm air from leaving. The greenhouse effect does not prevent the physical movement of warm and cool air.
    (f) High- and low-pressure areas describe conditions in air masses as a result of heating or cooling. They differ in their densities (and sometimes moisture content) — high pressure is denser than low pressure.
19. If Earth was much smaller than it actually is and did not rotate on its axis, convection currents would still begin at the equator, since it is closer to the Sun than are the higher latitudes. Warm air would expand, rise, travel northwards and southwards in a straight line until it reaching the Poles, cool, sink, and travel back to the equator, where the whole process would start again.
20. Between 30°S and the equator, the Coriolis effect causes north/south convection currents to veer west. This effect creates the southeast trade winds, which blow from the east and to the west.
21. A sea breeze is caused by differential heating as shown below:

During the day (called a sea breeze):
i. The Sun heats the land resulting in the air above the land rising to a much greater extent than the air over water, which is not as hot.
ii. This decreased pressure pulls air in from over the water.
iii. This decreased pressure pulls air from over the land to the water.
iv. This air cools and falls.
At night, the process reverses resulting in a land breeze.



22. Wind patterns in the atmosphere, ocean currents in the hydrosphere, and infrared radiation from the lithosphere are the major components of the climate system. Solar energy heats the Earth and

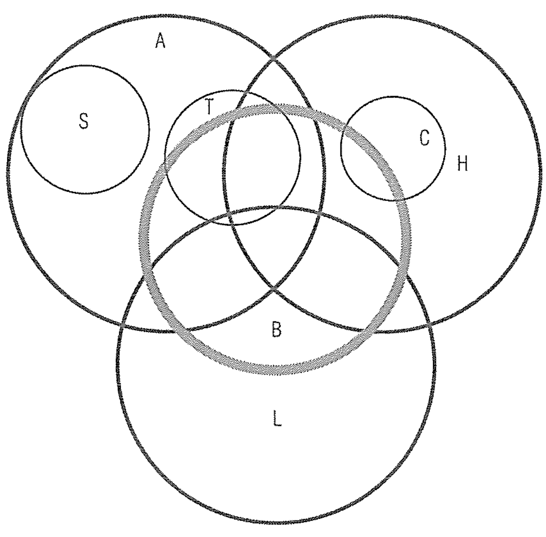
atmosphere, and ocean currents and winds distribute the heat from areas near the equator towards the higher latitudes. The Coriolis effect causes air currents to veer east at higher latitudes, and west below latitudes of 30°. El Niño and La Niña affect wind and ocean currents resulting in abnormal weather conditions. The ocean and other large bodies of water at nearby regions prevent the temperature from fluctuating radically from day to night, and the difference between the specific heat capacity of water and that of the land causes sea breezes during the day, and land breezes at night. Regions far from large bodies of water are less humid. Mountains also influence coastal winds and inland precipitation.

23 A mountain could influence the precipitation of a region in three ways: (i) increase the precipitation on the windward side (orographic precipitation); (ii) decrease the precipitation on the downwind (leeward) side (rain shadow effect); and (iii) result in snowcaps on top of the mountains.

Developing Skills

24. The specific heat of water (4.19 J/g•°C), is relatively high, therefore it takes more energy to heat water than the same amount of air or land. Likewise, the latent heat of vaporization of water is higher than that of other substances, so it takes more energy for water to evaporate than for other liquids to evaporate. As a result, large bodies of water have a moderating effect on the climate of coastal regions or regions by large lakes, because the water can absorb a great deal of heat.

25.



A = atmoshpere
T = troposphere
S = stratosphere
H = hydrosphere
C = cryosphere
B = biosphere
L = lithosphere

26. Jet streams form at the boundaries of cold and warm air. For example, when the prevailing westerlies meet up with the polar easterlies, the cooler, denser air pushes up beneath the warmer westerlies. Since the higher the warm air moves the fewer barriers it encounters, the air picks up speed, creating a jet stream.

27. **Given** Mass of iceberg,

$m = 50\ \text{t}\left(\frac{1000\ \text{kg}}{\text{t}}\right) \times \left(\frac{1000\ \text{g}}{\text{kg}}\right) = 5.0 \times 10^7\ \text{g}$

Specific heat capacity of ice, $c = \frac{2.00\ \text{J}}{\text{g•°C}}$

Change of temperature, $\Delta T = 0°\text{C} - (-15°\text{C}) = 15°\text{C}$

Required Energy required to heat iceberg, Q

Analysis Use $Q = mc\Delta T$. Solve for Q.

Solution $Q = mc\Delta T$

$= (5 \times 10^7\ \text{g})(\frac{2.00\ \text{J}}{\text{g•°C}})(15°\text{C})$

$Q = 1.5 \times 10^9\ \text{J}$

Paraphrase It takes 1.5×10^9 (2000 MJ) of energy change the temperature of a 50 t iceberg from −15°C to 0°C.

28. **Given** Mass of sea water, $m = 750$ g

Specific heat capacity of sea water, $c = 3.89\ \frac{\text{J}}{\text{g•°C}}$

Change of temperature, $\Delta T = 30°\text{C}$

Required Heat required to increase the temperature of 750 g of seawater by 30°C, Q

Analysis Use $Q = mc\Delta T$. Solve for Q.

Solution $Q = mc\Delta T$

$= (750\ \text{g})(3.89\ \frac{\text{J}}{\text{g•°C}})(30\ °\text{C})$

$= 87\ 525\ \text{J}$

$Q \approx 8.8 \times 10^4\ \text{J}$

Paraphrase It takes 8.8×10^4 J of thermal energy to increase the temperature of 750 g of seawater by 30°C.

29. **Given** Mass of dry air, $m = 145\ \text{kg} = 1.45 \times 10^5\ \text{g}$

Specific heat capacity of dry air, $c = 1.00\ \frac{\text{J}}{\text{g•°C}}$

Mass of moist air, $m = 145\ \text{kg} = 1.45 \times 10^5\ \text{g}$

Specific heat capacity of dry air, $c = 1.15\ \frac{\text{J}}{\text{g•°C}}$

Change of temperature, $\Delta T = T_2 - T_1 = 12°\text{C}$

Required Heat required to increase the temperature of 145 kg of dry air by 12°C, Q_1

Heat required to increase the temperature of 145 kg of moist air by 12°C, Q_2

Analysis Use $Q_1 = mc\Delta T$. Solve for Q_1.

Use $Q_2 = mc\Delta T$. Solve for Q_2.

Solution $Q_1 = mc\Delta T$

$= (1.45 \times 10^5\ \text{g})(1.00\ \frac{\text{J}}{\text{g•°C}})(12\ °\text{C})$

$= 1.74 \times 10^6\ \text{J}$

$Q_2 = mc\Delta T$

$= (1.45 \times 10^5\ \text{g})(1.15\ \frac{\text{J}}{\text{g•°C}})(12\ °\text{C})$

$= 2.0010000 \times 10^6\ \text{J}$

$Q_2 - Q_1 = 2.001000 \times 10^6\ \text{J} - 1.740000 \times 10^6\ \text{J}$

$= 2.61 \times 10^5\ \text{J}$

$\approx 2.6 \times 10^5\ \text{J}$

Paraphrase It takes 2.6×10^5 J $\times 10^5$ J thermal energy to increase the temperature of the 145 kg of moist air than 145 kg of dry air.

30. **Given** Mass of steam, $m = 720.8\text{g}$

Molar mass of water = $18.02 \frac{\text{g}}{\text{mol}}$

Number of moles of water,

$$n = \frac{m}{M} = \frac{720.8 \text{ g}}{18.02 \frac{\text{g}}{\text{mol}}}$$

$n = 40.00$ mol

Heat of fusion of water, $H_{\text{fus}} = 6.01 \frac{\text{kJ}}{\text{mol}}$

Specific heat capacity of pure water, $c = 4.19 \frac{\text{J}}{\text{g•°C}}$

Change of temperature, $\Delta T = 20°\text{C} - 100°\text{C} = -80°\text{C}$

Required Heat released when steam at 100°C condenses to water at 100°C, Q_1

Heat released when water at 100°C cools to water at 20°C, Q_2

Total heat released, $Q_{total} = Q_1 + Q_2$

Analysis Use $Q_1 = nH_{\text{fus}}$. Solve for Q_1.

Use $Q_2 = mc\Delta T$. Solve for Q_2.

Solution

$$Q_1 = nH_{\text{fus}} = (40.00 \text{ mol})(6.01 \frac{\text{kJ}}{\text{mol}}) = 240.4 \text{ kJ}$$

$$Q_2 = mc\Delta T = (720.8 \text{ g})(4.19 \frac{\text{J}}{\text{g•°C}})(80°\text{C}) = 2.4161216 \times 10^5 \text{ J}$$

$$Q_{\text{total}} = Q_1 + Q_2 = 240.4 \text{ kJ} + 241.61216 \text{ kJ} \approx 4.8 \times 10^2 \text{ kJ}$$

Paraphrase 4.8×10^2 kJ of thermal energy is released when 720.8g of steam at 100°C condenses to form water, which cools to 20°C.

Problem Solving/Applying

Critical Thinking

31. If Earth rotated in the opposite direction, Alberta's prevailing winds would be from the east (prevailing easterlies). This would happen because the Coriolis effect of a clockwise rotation results in the convection currents bending to the left.

32. (a) convection. A fan moves the warm air away from the skin.
 (b) conduction. Energetic molecules in and on the skin and collide with water molecules on the towel, passing energy to the water on the towel.
 Link to more information via
 www.mcgraw.hill.ca/links/sciencefocus10

Pause & Reflect You may wish to post students' paragraphs, encourage them to share their ideas in a small group, or create a bulletin board of "Surprises in Science."