**Unit 1: Sustaining Earth’s Ecosystems**

**Chapter 1 Biomes and ecosystems are divisions of the biosphere.**

**Section 1.1 Biomes**

**Cloze Activity**

Biomes and ecosystems
Page 4

1. biotic
2. abiotic
3. biome
4. terrestrial
5. temperature; precipitation
6. latitude
7. elevation
8. ocean currents
9. climatograph
10. adaptations
11. structural; physiological; behavioural

**Applying Knowledge**

**Various biomes**
Page 5

<table>
<thead>
<tr>
<th>BIOME</th>
<th>LOCATION(S)</th>
<th>PHYSICAL FEATURES</th>
</tr>
</thead>
</table>
| Grassland (temperate and tropical) | temperate: centre of North America (prairies) and in Russia (steppes) tropical: north and south of equator in Africa, South America, northern Australia | • flat land  
• strong winds  
• temperate: rich, fertile soil  
• tropical: heavy rain  
• precipitation followed by dry period |
| tropical rainforest         | around the equator: northern South America, Central America, central Africa, and southeast Asia | • poor soil  
• heavy rain  
• limited plant growth on forest floor due to canopy |
| desert (hot and cold)       | every continent                                                            | • hot desert:  
• very little rainfall or a lot in very short time period  
• salty soil  
• cold desert:  
• snow and spring rain  
• salty soil, little erosion |
| permanent ice (polar ice)   | polar land masses and ice caps of Arctic, Greenland, and Antarctica          | • strong winds  
• little soil  
• limited fresh water  
• very cold year round |

**Interpreting Illustrations**

**Climatographs**
Page 6

A. permanent ice  
B. boreal forest  
C. temperate rainforest  
D. grassland  
E. desert (hot)  
F. tropical rainforest

**Assessment**

**Biomes**
Page 7

1. C  
2. B  
3. E  
4. D  
5. F  
6. A  
7. D  
8. B  
9. C  
10. A  
11. B  
12. C
**Section 1.2 Ecosystems**

**Comprehension**

**Parts of an ecosystem**

**Page 10**

1. An ecosystem has abiotic components that interact with biotic components, while a habitat is the place in which an organism lives.

2. Three main abiotic components of ecosystems are (any three of) oxygen, water, nutrients, light, and soil.

3. A population refers to all the members of a particular species within an ecosystem, while a community is all the populations of different species within an ecosystem.

4. Symbiosis is the interaction between members of two different species that live together in a close association.

5. Commensalism is a symbiotic relationship in which one species benefits and the other species is not helped or harmed.

6. Mutualism is a symbiotic relationship in which both organisms benefit, while parasitism is a symbiotic relationship in which one species benefits and the other is harmed.

7. Predation is where one organism eats all or part of another organism.

**Interpreting illustrations**

**Biotic interactions in ecosystems**

**Page 11**

1. I. organism
   II. ecosystem
   III. population
   IV. community
   V. biosphere

2. Largest Biosphere
   Ecosystem
   Community
   Population
   Smallest Organism

3. Lists will vary but should include a variety of plants and animals.

**Applying Knowledge**

**Symbiotic relationships**

**Page 12**

1. Term: Mutualism
   Explanation: Both organisms benefit. The ant gets its food and shelter while the plant is protected from insects.

2. Term: Competition
   Explanation: Harmful interaction between two or more organisms as they compete for the same resource. The knapweed prevents other species from populating the soil by releasing a chemical.

3. Term: Predation
   Explanation: One organism (predator) eats all or part of another organism (the prey). The lynx is the predator and the snowshoe hare is the prey.

4. Term: Commensalism
   Explanation: One species benefits and the other species is not helped or harmed. The Spanish moss captures nutrients and moisture from the air with no harmful effects on the trees.

5. Term: Parasitism
   Explanation: One species benefits and another is harmed. The pine beetle has its food source and the pine tree is destroyed.

**Assessment**

**Ecosystems**

**Page 13**


**Chapter 2 Energy flow and nutrient cycles support life in ecosystems.**

**Section 2.1 Energy Flow in Ecosystems**

**Cloze activity**

**Energy flow**

**Page 16**

1. biomass
2. energy flow
3. photosynthesis
4. consumer
5. decomposition
6. biodegradation
7. decomposers
8. food chains; trophic
9. primary producers
10. primary consumers; secondary consumers
11. tertiary consumers
12. food webs; food pyramids

**Interpreting Illustrations**

**Food chains, food webs, and food pyramids**

**Page 17**

1. bunchgrass, algae
2. third trophic level
3. secondary consumers
4. primary consumer
5. secondary or tertiary consumer
6. earthworms, beetles, small insects, bacteria, fungi
7. a model that shows the loss of energy from one trophic level to another
8. producers, such as plants
9. carnivores, such as great horned owls

Illustrating Concepts
Modelling a local ecosystem
Page 19
1. Student should include 12 organisms and cover all four trophic levels.
2. Food chain: student should include four trophic levels: primary producers, primary consumers, secondary consumers, and tertiary consumers.
3. Food web: student should include interconnecting arrows between various organisms to demonstrate the feeding relationships.
4. Food pyramid: student should show a series of boxes decreasing in size from bottom to top. The pyramid should include producers, herbivores, carnivores, and top carnivores.

Assessment
Energy flow in ecosystems
Page 20

Section 2.2 Nutrient Cycles in Ecosystems
Comprehension
Nutrient cycles
Page 24
1. Nutrients are stored in Earth’s atmosphere, oceans, and land masses.
2. Biotic processes, such as decomposition, and abiotic processes, such as river run-off, can cause nutrients to flow in and out of stores.
3. Photosynthesis converts solar energy into chemical energy. Carbon, in the form of carbon dioxide, enters through the leaves of plants and, in the presence of sunlight, reacts with water to produce carbohydrates and oxygen.
4. Cellular respiration involves carbohydrates reacting with oxygen to form carbon dioxide, water, and energy.
5. Decomposers, such as bacteria and fungi, convert organic molecules, such as cellulose, back into carbon dioxide, which is then released into the atmosphere.
6. Nitrogen fixation is the process in which nitrogen gas is converted into compounds that contain nitrate or ammonium.
7. Denitrification is a process by which denitrifying bacteria, using a series of chemical reactions, convert nitrate back into nitrogen gas.
8. Eutrophication is the process by which excess nutrients result in increased plant production and decay in aquatic ecosystems.

Interpreting Illustrations
The cycling of nutrients in the biosphere
Page 25
1. Human activities that can affect a nutrient cycle could include land clearing, agriculture, urban expansion, mining, industry, and motorized transportation.
2. These human activities increase the amounts of nutrients in a cycle faster than natural biotic and abiotic processes can move them back into stores.
3. Terms and arrows could be similar to Fig 2.17 on page 70. Students may also add other facts or effects that they have thought of.
4. Changes in the carbon, nitrogen, and phosphorus cycles can affect the health and variety of organisms that live in an ecosystem.
5. Answers will vary but they should include a human activity, a description of the activity, and its impact on a specific part of the local ecosystem.

Applying Knowledge
The carbon, nitrogen, and phosphorus cycles
Page 26
The carbon cycle

<table>
<thead>
<tr>
<th>Why is the carbon cycle important?</th>
<th>cellular respiration provides energy for living things</th>
</tr>
</thead>
<tbody>
<tr>
<td>How is carbon stored?</td>
<td>short term: vegetation, land and marine animals, decaying organic material, carbon dioxide in its dissolved form</td>
</tr>
<tr>
<td></td>
<td>long term: dissolved carbon dioxide in deeper ocean waters; coal, oil, and gas deposits; marine sediments and sedimentary rock</td>
</tr>
<tr>
<td>How is carbon cycled?</td>
<td>photosynthesis, respiration, decomposition, ocean processes, volcanic eruptions, forest fires</td>
</tr>
</tbody>
</table>
The nitrogen cycle

Why is the nitrogen cycle important? component of DNA, proteins, muscle function in animals; growth of plants

How is nitrogen stored? nitrogen gas in atmosphere, oceans, organic matter in soil

How is nitrogen cycled? nitrogen fixation, nitrification, uptake, denitrification

Name several human activities that affect the nitrogen cycle. fossil fuel combustion, power plants, sewage treatment, motorized forms of transport, clearing forests, grassland burning, chemical fertilizers leading to eutrophication

The phosphorus cycle

Why is the phosphorus cycle important? carries energy to plant cells and animal cells; root development in plants; bone development

How is phosphorus stored? phosphate rock; ocean floor sediments as $\text{PO}_4^{3-}$, $\text{HPO}_4^{2-}$, $\text{H}_2\text{PO}_4^-$

How is phosphorus cycled? chemical weathering, physical weathering

Name several human activities that affect the phosphorus cycle. commercial fertilization and detergents negatively affect species, causing fish death

Assessment

Nutrient cycles in ecosystems

Page 29


Section 2.3 Effects of Bioaccumulation on Ecosystems

Cloze activity

Bioaccumulation

Page 33

1. bioaccumulation
2. keystone species
3. biomagnification
4. producers
5. PCBs
6. half-life
7. persistent organic pollutants
8. parts per million
9. heavy metals

10. lead; cadmium; mercury

11. bioremediation

Applying Knowledge

Impact of bioaccumulation on consumers

Page 34

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>EFFECTS ON PRODUCERS, PRIMARY CONSUMERS, AND SECONDARY CONSUMERS</th>
<th>EFFECTS ON HUMANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>toxic organic chemicals from red tide</td>
<td>Produces toxic chemicals that affect clams, mussels, and oysters. Toxins bioaccumulate in fish and mammals.</td>
<td>Can cause paralytic shellfish poisoning, leading to serious illness or death.</td>
</tr>
<tr>
<td>DDT</td>
<td>Bioaccumulates in plants and then in fatty tissue of fish, birds, and animals that eat the plants. Affects aquatic food chains.</td>
<td>Changed into a chemical form that is stored in fat tissue. Can cause nervous system, immune system, and reproductive disorders.</td>
</tr>
<tr>
<td>lead</td>
<td>In fish and birds it can cause nervous system damage, affect fertility rates, kidney failure, and impair mental development.</td>
<td>Harmful effects range from anemia, nervous system damage, sterility in men, low fertility rates in women, impaired mental development, and kidney failure.</td>
</tr>
<tr>
<td>cadmium</td>
<td>Plants take up cadmium from the soil and pass it on to the animals that eat them. Highly toxic to earthworms and other soil organisms. In fish, cadmium contributes to higher death rates, and lower reproduction and growth rates.</td>
<td>Accumulates in lung tissues, causing lung diseases, such as cancer. Leads to infertility and damage to central nervous system, immune system, and DNA.</td>
</tr>
<tr>
<td>mercury</td>
<td>Bacteria change mercury into methylmercury, a toxin that accumulates in the brain, heart, and kidneys of vertebrates. Levels of methylmercury in fish depend on how high they are on the food chain.</td>
<td>Methylmercury is absorbed in digestion and enters the blood and then the brain. It affects nerve cells, heart, kidney, lungs, and it suppresses the immune system.</td>
</tr>
</tbody>
</table>
Comprehension
PCBs and the orca
Page 36
1. PCBs are synthetic chemicals. Their full chemical name is polychlorinated biphenyl.
2. PCBs were used for industrial products, such as heat exchange fluids, paints, plastics, and lubricants for electrical transformers.
3. PCBs stay in the environment for a long time. Aquatic ecosystems and species that feed on aquatic organisms are especially sensitive to the effects of PCBs. PCBs bioaccumulate and biomagnify and also have a long half-life.
4. PCBs become concentrated in the orca’s blubber.
5. When salmon stocks are low, the orca’s blubber is burned for energy. The PCBs are released into the orca’s bloodstream and interfere with its immune system making it more susceptible to disease.

Assessment
Effects of bioaccumulation on ecosystems
Page 37

Chapter 3 Ecosystems continually change over time.

Section 3.1 How Changes Occur Naturally in Ecosystems
Cloze Activity
Change in ecosystems
Page 40
1. natural selection
2. adaptive radiation
3. ecological succession
4. primary succession
5. pioneer species
6. climax community
7. secondary succession
8. flooding
9. tsunami
10. drought
11. insect infestations

Analyzing Information
Primary and secondary succession
Page 41
1. Answer should include the following sequence:
   - Lichens begin to grow. This begins the process of soil formation.
   - Plants, such as mosses, begin to grow.
   - Insects, micro-organisms, and other organisms move in.
   - Grasses, wildflowers, and shrubs begin to grow. More insects and micro-organisms move in.
   - Tree seeds are transported by animals. Deciduous trees grow.
   - Coniferous trees germinate.
   - Mature community develops.
2. Answer should include the following sequence:
   - Exposed soil will contain micro-organisms, worms, and insects as well as the seeds of wildflowers, weeds, grasses, and trees.
   - Other seeds may blow in or be carried in by animals.
   - Deciduous trees grow.
   - Coniferous trees return.
   - Mature community may only take decades to establish.

Applying Knowledge
How natural events affect ecosystems
Page 42

<table>
<thead>
<tr>
<th>NATURAL EVENT</th>
<th>EFFECTS ON MATURE COMMUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>• causes secondary succession</td>
</tr>
<tr>
<td></td>
<td>• results in regrowth</td>
</tr>
<tr>
<td>Flooding</td>
<td>• causes soil erosion</td>
</tr>
<tr>
<td></td>
<td>• results in soil and water pollution, leading to widespread disease</td>
</tr>
<tr>
<td>Tsunami</td>
<td>• water carries away or destroys plants and animals</td>
</tr>
<tr>
<td></td>
<td>• disrupts habitats and food webs</td>
</tr>
<tr>
<td></td>
<td>• salt from salt water changes composition of soil</td>
</tr>
<tr>
<td>Drought</td>
<td>• destroys habitats</td>
</tr>
<tr>
<td></td>
<td>• results in the death of plants and animals</td>
</tr>
<tr>
<td></td>
<td>• leads to crop failures and livestock deaths</td>
</tr>
<tr>
<td>Insect Infestation</td>
<td>• results in losses to forest canopy</td>
</tr>
<tr>
<td></td>
<td>• disrupts habitats and food webs</td>
</tr>
</tbody>
</table>

Assessment
How changes occur naturally in ecosystems
Page 43
Section 3.2 How Humans Influence Ecosystems

Comprehension
Sustainability
Page 46

1. Sustainability is the ability of an ecosystem to sustain ecological processes and maintain biodiversity over time. It also means that humans use natural resources in a way that maintains ecosystem health now and for future generations.

2. Habitat loss refers to the destruction of habitats while habitat fragmentation is the division of habitats into smaller, isolated fragments.

3. Deforestation is the practice in which forests are logged or cleared for human use and never reforested. This practice results in a reduction of the number of plants and animals living in an ecosystem. Erosion occurs since few plants are left to hold the soil in place. As a result of the erosion, nutrients are lost so plants are not able to grow.

4. Aeration, or breaking up compacted soil, reduces run-off by improving the movement of air and water through soil.

5. Examples of contamination due to mining could include introduction of chemicals, toxins, wastes, or micro-organisms into the environment.

6. Overexploitation can result in extinction of a species and a loss of genetic diversity. In turn, the populations are less resistant to disease and less able to adapt to changes in their environment.

7. Traditional ecological knowledge takes the form of stories, songs, cultural beliefs, rituals, community laws, and practices related to agriculture, forests, and ocean resources. It reflects the knowledge about local climate and resources, biotic and abiotic characteristics, and animal and plant cycles.

Applying Knowledge
Effects of human activities on ecosystems
Page 47

<table>
<thead>
<tr>
<th>HUMAN ACTIVITY</th>
<th>EFFECTS ON ECO SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>deforestation</td>
<td>• reduction in number of plants and animals living in an ecosystem</td>
</tr>
<tr>
<td></td>
<td>• erosion due to lack of plant roots holding soil in place</td>
</tr>
<tr>
<td></td>
<td>• removal of nutrients from topsoil</td>
</tr>
<tr>
<td>agricultural practices, such as leaving fields bare during non-planting seasons</td>
<td>• wind erosion</td>
</tr>
<tr>
<td></td>
<td>• soil compaction</td>
</tr>
<tr>
<td></td>
<td>• hindering growth of plants</td>
</tr>
<tr>
<td></td>
<td>• addition of excess nitrogen and pollutants due to increased run-off</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HUMAN ACTIVITY</th>
<th>EFFECTS ON ECOSYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>exploitation of mining resources</td>
<td>• contamination of ground water and surface water through introduction of chemicals, toxins, wastes, or micro-organisms</td>
</tr>
<tr>
<td></td>
<td>• contaminants affect local plant and animals</td>
</tr>
<tr>
<td>overexploitation of natural resources, such as fish</td>
<td>• reduction in population of particular fish</td>
</tr>
<tr>
<td></td>
<td>• loss of genetic diversity in food web</td>
</tr>
<tr>
<td></td>
<td>• species less resistant to disease and changes in environment</td>
</tr>
</tbody>
</table>

Analyzing Information
Sustainability
Page 48

<table>
<thead>
<tr>
<th>EXAMPLE OF LAND USE</th>
<th>EFFECTS ON HABITAT</th>
<th>SUSTAINABLE APPROACH SUGGESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>the conversion of grasslands into cattle ranches in the Interior of British Columbia</td>
<td>• livestock overgrazing</td>
<td>• grassland management programs</td>
</tr>
<tr>
<td></td>
<td>• soil compaction</td>
<td>• protection of natural grasslands</td>
</tr>
<tr>
<td></td>
<td>• vehicles cause erosion and plant destruction</td>
<td>• aeration</td>
</tr>
<tr>
<td></td>
<td>• introduced plants compete with native plants</td>
<td>• weed control</td>
</tr>
<tr>
<td>clear-cutting of forests on Vancouver Island</td>
<td>• erosion</td>
<td>• forestry management practices that allow more trees to remain uncut</td>
</tr>
<tr>
<td></td>
<td>• stream habitat destruction</td>
<td>• streambed restoration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• less harmful road-building</td>
</tr>
</tbody>
</table>

| urbanization of the Fraser Valley                    | • biodiversity loss                                          | • redevelopment of industrial areas or buildings |
|                                                   | • greater reliance on motorized vehicles                     | • mix of residence, business, and industry |
|                                                   | • increased energy consumption                               | • waste treatment                  |
|                                                   |                                                             | • storm water collection           |
|                                                   |                                                             | • native plantings                |
|                                                   |                                                             | • additional green areas          |

Assessment
How humans influence ecosystems
Page 49

### Section 3.3 How Introduced Species Affect Ecosystems

#### Comprehension

**Introduced species**

**Page 52**

1. Native species are plants and animals that naturally inhabit an area.

2. An invasive species are organisms that can take over the habitat of native species or invade their bodies.

3. Invasive species often have high reproduction rates, are aggressive competitors, and lack natural predators in their new habitat. Exploiting the new niche, an invasive species can dramatically change an ecosystem.

4. An introduced species can affect a native species through competition, predation, disease, parasitism, and habitat alteration.

5. Examples could include Eurasian milfoil, purple loosestrife, Norway rat, American bullfrog, European starling, Scotch broom, English ivy, and invasive grasses.

6. Scotch broom, English ivy, and invasive grasses are competing with Garry oak trees.

7. Scotch broom produces up to 18,000 seeds per plant. Its yellow flower attracts bees for pollination and it is well adapted for drought.

#### Applying Knowledge

**The impact of introduced invasive species**

**Page 53**

Answers could vary depending on the ecosystem. Answers given are referenced from textbook pages 140–141.

<table>
<thead>
<tr>
<th>METHOD</th>
<th>INVASIVE SPECIES</th>
<th>EFFECT ON ECOSYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>disease and/or parasites</td>
<td>parasitic lampreys</td>
<td>• lampreys use sucker-like mouths to attach to fish, then suck the body fluids from prey</td>
</tr>
<tr>
<td></td>
<td>blister rust</td>
<td>• blister rust fungus weakens whitebark pine tree defenses making it more vulnerable to insect infestations</td>
</tr>
<tr>
<td>habitat alteration</td>
<td>wild boars</td>
<td>• damage environment by rooting and wallowing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• spread weeds that interfere with natural succession</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• eat native birds, reptiles, frogs, soil organisms, fruit, seeds, and bulbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• boars are considered world’s most invasive species</td>
</tr>
<tr>
<td>competition</td>
<td>carpet burweed</td>
<td>• burweed competes with four native plants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• spiny tips pierce skin of animals and humans</td>
</tr>
<tr>
<td>predation</td>
<td>yellow crazy ants</td>
<td>• ants build supercolonies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• devour all plants and prey on young of reptiles, birds, and mammals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ants killed 20 million land crabs on Christmas Island</td>
</tr>
<tr>
<td>American bullfrog</td>
<td>brought to British Columbia in 1930s for frogs’ legs in restaurants</td>
<td>• takes over habitats</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• eats native frogs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• attacks ducks and small mammals</td>
</tr>
<tr>
<td>European starling</td>
<td>late 1800s, fifty pairs brought to North America</td>
<td>• outcompetes native birds for nesting sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• devastates fruit and grain crops</td>
</tr>
<tr>
<td>Scotch broom</td>
<td>Mid-1800s, introduced as decorative garden plant</td>
<td>• replaces native scrubs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ruins habitat for native birds and butterflies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• creates an overload of nitrogen that interferes with growth of some native species</td>
</tr>
</tbody>
</table>

#### Extension Activity

**Invasive species in British Columbia**

**Page 54**

Answers may include:

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>METHOD OF INTRODUCTION</th>
<th>EFFECT ON ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>purple loosestrife</td>
<td>seeds from Europe in 1800s</td>
<td>• destroys wetlands and chokes out other plants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• too dense to effectively shelter wildlife</td>
</tr>
<tr>
<td>Eurasian milfoil</td>
<td>brought to North America in 1800s</td>
<td>• cuts off sunlight to organisms below</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• interferes with recreational activities</td>
</tr>
<tr>
<td>Norway rat</td>
<td>escaped from early European explorer and fur-trading ships</td>
<td>• feeds on any food source</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• eats eggs and young of ground-nesting sea birds, causing their decline</td>
</tr>
<tr>
<td>American bullfrog</td>
<td>brought to British Columbia in 1930s for frogs’ legs in restaurants</td>
<td>• takes over habitats</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• eats native frogs</td>
</tr>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td>• ruins habitat for native birds and butterflies</td>
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<tr>
<td></td>
<td></td>
<td>• creates an overload of nitrogen that interferes with growth of some native species</td>
</tr>
</tbody>
</table>
UNIT 2 Chemical Reactions and Radioactivity

Chapter 4 Atomic theory explains the formation of compounds.

Section 4.1 Atomic Theory and Bonding

Comprehension

The atom and the subatomic particles

<table>
<thead>
<tr>
<th>Atomic Number</th>
<th>Ion Charge</th>
<th>Number of Protons</th>
<th>Number of Electrons</th>
<th>Number of Neutrons</th>
<th>Number of Electron Shells</th>
</tr>
</thead>
<tbody>
<tr>
<td>neon atom</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>fluorine atom</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>fluorine ion</td>
<td>9</td>
<td>9</td>
<td>10</td>
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<td>10</td>
<td>12</td>
<td>2</td>
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</table>

3.

Illustrating Concepts

Lewis diagrams

1. (a) a diagram that illustrates chemical bonding by showing only an atom’s valence electrons and the chemical symbol

(b) pair of electrons in the valence shell that is not used in bonding

(c) pair of electrons involved in a covalent bond

2. (a) \( \cdot O \cdot \)

(b) \( \cdot N \cdot \)

(c) \( \cdot Al \cdot \)

(d) \( \cdot Cl \cdot \)

3. (a) \([Na]^+ \cdot [Cl]^− \cdot [Na]^+\)

(b) \([K]^+ \cdot [Cl]^−\)
Section 4.2 Names and Formulas of Compounds

Comprehension

Multivalent metals and polyatomic ions

Page 68

1. (a) a compound made up of a metal and a non-metal
(b) a metal that has more than one ion charge
(c) an ion composed of more than one type of atom joined by covalent bonds

2.

<table>
<thead>
<tr>
<th>Positive ion</th>
<th>Negative ion</th>
<th>Formula</th>
<th>Compound name</th>
</tr>
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<tr>
<td>(a) Pb⁴⁺</td>
<td>O²⁻</td>
<td>PbO</td>
<td>lead(II) oxide</td>
</tr>
<tr>
<td>(b) Sb⁴⁺</td>
<td>S²⁻</td>
<td>Sb₂S₃</td>
<td>antimony(IV) sulphide</td>
</tr>
<tr>
<td>(c) Ti⁴⁺</td>
<td>Cl⁻</td>
<td>TiCl</td>
<td>thallium(I) chloride</td>
</tr>
<tr>
<td>(d) Sn²⁺</td>
<td>F⁻</td>
<td>SnF₂</td>
<td>tin(II) fluoride</td>
</tr>
<tr>
<td>(e) Mo⁵⁺</td>
<td>S²⁻</td>
<td>Mo₅S₉</td>
<td>molybdenum(III) sulphide</td>
</tr>
<tr>
<td>(f) Rh⁵⁺</td>
<td>Br⁻</td>
<td>RhBr₆</td>
<td>rhodium(IV) bromide</td>
</tr>
<tr>
<td>(g) Cu⁺</td>
<td>Te²⁻</td>
<td>Cu₂Te</td>
<td>copper(II) telluride</td>
</tr>
<tr>
<td>(h) Nb⁶⁺</td>
<td>I⁻</td>
<td>NbI₅</td>
<td>niobium(V) iodide</td>
</tr>
<tr>
<td>(i) Pd²⁺</td>
<td>Cl⁻</td>
<td>PdCl₂</td>
<td>palladium(II) chloride</td>
</tr>
</tbody>
</table>
(h) manganese(III) oxide
(i) chromium(III) sulphate
(j) zinc chloride
(k) nickel(II) hydroxide
(l) potassium dichromate
(m) scandium fluoride
(n) sodium iodide
(o) lead(II) carbonate
(p) rubidium chloride
(q) potassium phosphide
(r) magnesium cyanide
(s) tin(II) sulphide
(t) sodium bicarbonate or sodium hydrogen carbonate

2. (a) AlBr₃
(b) PtS
(c) SrSO₃
(d) Sc₂O₃
(e) Ti(NO₃)₄
(f) (NH₄)₂SO₄
(g) Li₂Se
(h) Pb(HSO₄)₂
(i) NaCH₃COO
(j) CsCl
(k) Cd(OH)₂
(l) Zn₃(PO₄)₂
(m) BaCl₂
(n) Sn(MnO₄)₂
(o) LiClO
(p) Au₂(SO₄)₃
(q) NaNO₃
(r) CrCl₃
(s) K₂CO₃
(t) Fe(HSO₄)₃

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Word List

<table>
<thead>
<tr>
<th>ACROSS</th>
<th>DOWN</th>
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</thead>
<tbody>
<tr>
<td>Arsenic trioxide</td>
<td>1. S₂O₃</td>
</tr>
<tr>
<td>Boron monoxide</td>
<td>1. P₂O₃</td>
</tr>
<tr>
<td>Carbon disulphide</td>
<td>2. As₂O₅</td>
</tr>
<tr>
<td>Chlorine monoxide</td>
<td>3. PBr₃</td>
</tr>
<tr>
<td>Darsenic pentoxide</td>
<td>4. SCl₂</td>
</tr>
<tr>
<td>Dichlorine heptoxide</td>
<td>5. SiF₄</td>
</tr>
<tr>
<td>Dinitrogen trioxide</td>
<td>6. Cl₂O₇</td>
</tr>
<tr>
<td>Disulphur dichloride</td>
<td>7. Cl₂O₅</td>
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<tr>
<td>Iodine trichloride</td>
<td>8. NO</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>9. N₂O₅</td>
</tr>
<tr>
<td>Nitrogen monoxide</td>
<td>10. TeBr₃</td>
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<tr>
<td>Phosphorus tribromide</td>
<td>11. Pb₃</td>
</tr>
<tr>
<td>Silicon tetrachloride</td>
<td>12. BO</td>
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<tr>
<td>Sulphur tetrachloride</td>
<td>13. NO₂</td>
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<tr>
<td>Tellurium dibromide</td>
<td>14. TeCl₃</td>
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<tr>
<td>Tellurium trioxide</td>
<td>15. ClO₂</td>
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<tr>
<td>Tellurium trioxide</td>
<td>16. As₂O₃</td>
</tr>
</tbody>
</table>
Assessment
Names and formulas of compounds
Page 73
12. B

Section 4.3 Chemical Equations

Comprehension
Balancing equations
Page 77
1. \( \text{H}_2 + \text{F}_2 \rightarrow 2 \text{HF} \)
2. \( 2 \text{Sn} + \text{O}_2 \rightarrow 2 \text{SnO} \)
3. \( \text{MgCl}_2 \rightarrow \text{Mg} + \text{Cl}_2 \)
4. \( 2 \text{KNO}_3 \rightarrow 2 \text{KNO}_2 + \text{O}_2 \)
5. \( 2 \text{BN} + 3 \text{F}_2 \rightarrow 2 \text{BF}_3 + \text{N}_2 \)
6. \( \text{CuI}_2 + \text{Fe} \rightarrow \text{FeI}_2 + \text{Cu} \)
7. \( 2 \text{Li} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH} + \text{H}_2 \)
8. \( 4 \text{NH}_3 + 3 \text{O}_2 \rightarrow 2 \text{N}_2 + 6 \text{H}_2\text{O} \)
9. \( \text{V}_2\text{O}_5 + 5 \text{Ca} \rightarrow 5 \text{CaO} + 2 \text{V} \)
10. \( 2 \text{C}_9\text{H}_6\text{O}_4 + 17 \text{O}_2 \rightarrow 18 \text{CO}_2 + 6 \text{H}_2\text{O} \)
11. \( \text{H}_2\text{S} + \text{PbCl}_2 \rightarrow \text{PbS} + 2 \text{HCl} \)
12. \( 2 \text{C}_3\text{H}_7\text{OH} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 8 \text{H}_2\text{O} \)
13. \( \text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4 \)
14. \( \text{C}_6\text{H}_12\text{O}_6 + 6 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} \)
15. \( \text{C}_2\text{H}_5\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O} \)
16. \( 2 \text{Al} + 3 \text{H}_2\text{SO}_4 \rightarrow 3 \text{H}_2 + \text{Al}_2(\text{SO}_4)_3 \)
17. \( 2 \text{FeCl}_3 + 3 \text{Ca(OH)}_2 \rightarrow 2 \text{Fe(OH)}_3 + 3 \text{CaCl}_2 \)
18. \( \text{Pb(NO}_3)_2 + \text{K}_2\text{CrO}_4 \rightarrow \text{PbCrO}_4 + 2 \text{KNO}_3 \)
19. \( \text{Cd(NO}_3)_2 + (\text{NH}_4)_2\text{S} \rightarrow \text{CdS} + 2 \text{NH}_4\text{NO}_3 \)
20. \( \text{Ca(OH)}_2 + 2 \text{NH}_4\text{Cl} \rightarrow 2 \text{NH}_3 + \text{CaCl}_2 + 2 \text{H}_2\text{O} \)

Applying Knowledge
Word equations
Page 78
1. \( \text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} \)
2. \( \text{Fe}_2\text{O}_3 + 3 \text{H}_2 \rightarrow 3 \text{H}_2\text{O} + 2 \text{Fe} \)
3. \( 2 \text{Na} + 2 \text{H}_2\text{O} \rightarrow 2 \text{NaOH} + \text{H}_2 \)
4. \( \text{Ca}_2\text{C} + \text{O}_2 \rightarrow 2 \text{Ca} + \text{CO}_2 \)
5. \( 2 \text{KI} + \text{Cl}_2 \rightarrow 2 \text{KCl} + \text{I}_2 \)
6. \( 4 \text{Cr} + 3 \text{SnCl}_4 \rightarrow 4 \text{CrCl}_3 + 3 \text{Sn} \)
7. \( \text{Mg} + \text{CuSO}_4 \rightarrow \text{MgSO}_4 + \text{Cu} \)
8. \( \text{ZnSO}_4 + \text{SrCl}_2 \rightarrow \text{ZnCl}_2 + \text{SrSO}_4 \)
9. \( 3 \text{NH}_4\text{Cl} + \text{Pb(NO}_3)_2 \rightarrow 3 \text{NH}_4\text{NO}_3 + \text{PbCl}_4 \)
10. \( 2 \text{Fe(NO}_3)_3 + 3 \text{MgS} \rightarrow \text{Fe}_2\text{S}_3 + 3 \text{Mg(NO}_3)_2 \)
11. \( 2 \text{AlCl}_3 + 3 \text{Na}_2\text{CO}_3 \rightarrow \text{Al}_2(\text{CO}_3)_3 + 6 \text{NaCl} \)
12. \( 2 \text{Na}_3\text{PO}_4 + 3 \text{Ca(OH)}_2 \rightarrow 6 \text{NaOH} + \text{Ca}_3(\text{PO}_4)_2 \)

Extension
Chemical reactions and chemical equations
Page 79
1. iron + oxygen \( \rightarrow \) iron(II) oxide
   \( 2\text{Fe} + \text{O}_2 \rightarrow 2 \text{FeO} \)
2. hydrogen chloride + sodium carbonate \( \rightarrow \) carbon
dioxide + sodium chloride + water
   \( 2 \text{HCl} + \text{Na}_2\text{CO}_3 \rightarrow \text{CO}_2 + 2 \text{NaCl} + \text{H}_2\text{O} \)
3. aluminium + oxygen \( \rightarrow \) aluminium oxide
   \( 4 \text{Al} + 3 \text{O}_2 \rightarrow 2 \text{Al}_2\text{O}_3 \)
4. water + sodium oxide \( \rightarrow \) sodium hydroxide
   \( \text{H}_2\text{O} + \text{Na}_2\text{O} \rightarrow 2 \text{NaOH} \)
5. hydrogen + nitrogen trifluoride \( \rightarrow \) nitrogren + hydrogen fluoride
   \( 3 \text{H}_2 + 2 \text{NF}_3 \rightarrow \text{N}_2 + 6 \text{HF} \)
6. chromium(III) sulphate + potassium carbonate \( \rightarrow \) chromium(III) carbonate + potassium sulphate
   \( \text{Cr}_2(\text{SO}_4)_3 + 3 \text{K}_2\text{CO}_3 \rightarrow \text{Cr}_2(\text{CO}_3)_3 + 3 \text{K}_2\text{SO}_4 \)
7. potassium chlorate \( \rightarrow \) oxygen + potassium chloride
   \( 2 \text{KClO}_3 \rightarrow 3 \text{O}_2 + 2 \text{KCl} \)
8. zinc + copper(II) sulphate \( \rightarrow \) copper + zinc sulphate
   \( \text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4 \)

Assessment
Chemical equations
Page 80

Chapter 5 Compounds are classified in
different ways.

Section 5.1 Acids and Bases

Applying Knowledge
pH scale and pH indicators
Page 84
1. (a) chemical that changes colour depending on the
   pH of the solution it is placed in
   (b) number scale for measuring how acidic or basic a
   solution is
2. (a)

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>Methyl Orange</th>
<th>Bromothymol Blue</th>
<th>Litmus</th>
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<tr>
<td>lemon</td>
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<td>red</td>
<td>yellow</td>
<td>red</td>
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<tr>
<td>ammonia</td>
<td>11</td>
<td>base</td>
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<td>blue</td>
<td>blue</td>
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<tr>
<td>milk</td>
<td>6</td>
<td>acid</td>
<td>yellow</td>
<td>yellow</td>
<td>red</td>
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Comprehension
Names of acids
Page 86
1. ate
2. ite
3. (a) carbonic acid
   (b) acetic acid
   (c) phosphoric acid
   (d) chlorous acid
   (e) sulphurous acid
   (f) nitric acid
   (g) hydrofluoric acid
   (h) hydrochloric acid
4. (a) HI
   (b) H₂SO₄
   (c) HClO₄
   (d) HNO₂
   (e) HClO₃
   (f) HBr
   (g) H₃PO₃
   (h) HClO

Applying Knowledge
Acids versus bases
Page 87

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>pH Indicator</th>
<th>Colour of pH Indicator</th>
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<td>tomato</td>
<td>4</td>
<td>acid</td>
<td>red</td>
<td>colourless blue</td>
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<tr>
<td>oven cleaner</td>
<td>13</td>
<td>base</td>
<td>yellow</td>
<td>pink</td>
</tr>
<tr>
<td>egg</td>
<td>8</td>
<td>base</td>
<td>yellow</td>
<td>colourless blue</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>pH Indicator</th>
<th>Colour of pH Indicator</th>
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<td>black coffee</td>
<td>5</td>
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<td>litmus</td>
<td>red</td>
</tr>
<tr>
<td>milk of magnesia</td>
<td>10</td>
<td>base</td>
<td>phenolphthalein</td>
<td>pink</td>
</tr>
<tr>
<td>battery acid</td>
<td>0</td>
<td>acid</td>
<td>bromothymol blue</td>
<td>yellow</td>
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<td>base</td>
<td>indigo carmine</td>
<td>blue</td>
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<td>orange juice</td>
<td>3</td>
<td>acid</td>
<td>methyl orange</td>
<td>red</td>
</tr>
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<td>liquid drain cleaner</td>
<td>14</td>
<td>base</td>
<td>methyl red</td>
<td>yellow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH Value</th>
<th>Acid or Base</th>
<th>pH Indicator</th>
<th>Colour of pH Indicator</th>
</tr>
</thead>
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<td>black coffee</td>
<td>5</td>
<td>acid</td>
<td>litmus</td>
<td>red</td>
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<tr>
<td>milk of magnesia</td>
<td>10</td>
<td>base</td>
<td>phenolphthalein</td>
<td>pink</td>
</tr>
<tr>
<td>battery acid</td>
<td>0</td>
<td>acid</td>
<td>bromothymol blue</td>
<td>yellow</td>
</tr>
<tr>
<td>sea water</td>
<td>8</td>
<td>base</td>
<td>indigo carmine</td>
<td>blue</td>
</tr>
<tr>
<td>orange juice</td>
<td>3</td>
<td>acid</td>
<td>methyl orange</td>
<td>red</td>
</tr>
<tr>
<td>liquid drain cleaner</td>
<td>14</td>
<td>base</td>
<td>methyl red</td>
<td>yellow</td>
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ACIDS         BASES

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<th></th>
<th>ACIDS</th>
<th>BASES</th>
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<tr>
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<td>compounds containing hydrogen that produce a solution with a pH of less than 7 when they dissolve in water and that produce a salt and water when they react with ionic compounds containing hydroxide ions</td>
<td>chemical compounds containing hydroxide that produce a solution with a pH of more than 7 when they dissolve in water and produce a salt and water when they react with ionic compounds containing positive hydrogen ions</td>
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<tr>
<td>pH</td>
<td>&lt; 7</td>
<td>&gt; 7</td>
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<tr>
<td>what to look for in chemical formula</td>
<td>H</td>
<td>OH</td>
</tr>
<tr>
<td>production of ions</td>
<td>H⁺</td>
<td>OH⁻</td>
</tr>
<tr>
<td>electrical conductivity</td>
<td>conductive</td>
<td>conductive</td>
</tr>
<tr>
<td>taste</td>
<td>taste sour</td>
<td>taste bitter</td>
</tr>
<tr>
<td>touch</td>
<td>burn skin</td>
<td>feel slippery; burn skin</td>
</tr>
<tr>
<td>examples</td>
<td>HCl, H₂SO₄, lemons, stomach acid</td>
<td>NaOH, KOH, drain cleaner, soap</td>
</tr>
</tbody>
</table>

Assessment
Acids and bases
Page 88
Section 5.2 Salts

Comprehension
Recognizing acids, bases, and salts
Page 91
1. (a) acid
(b) acid
(c) base
(d) acid
(e) base
(f) acid
(g) acid
(h) acid
(i) salt
(j) base
(k) base
(l) salt
(m) acid
(n) salt
(o) salt
(p) salt
(q) acid
(r) acid
(s) base
(t) acid
(u) acid
(v) salt
2. acetic acid, \( \text{CH}_3\text{COOH} \)
3. sodium chloride, \( \text{NaCl} \)
4. sulphuric acid, \( \text{H}_2\text{SO}_4 \)
5. sodium hydroxide, \( \text{NaOH} \)
6. magnesium hydroxide, \( \text{Mg(OH)}_2 \)
7. hydrochloric acid, \( \text{HCl} \)

Applying Knowledge
Acid-base neutralization reactions
Page 92
1. (a) \( \text{H}_2\text{SO}_4 + 2 \text{NaOH} \rightarrow 2 \text{H}_2\text{O} + \text{Na}_2\text{SO}_4 \)
(b) \( \text{HNO}_3 + \text{KOH} \rightarrow \text{H}_2\text{O} + \text{KNO}_3 \)
(c) \( 2 \text{HCl} + \text{Ca(OH)}_2 \rightarrow 2 \text{H}_2\text{O} + \text{CaCl}_2 \)
(d) \( 2 \text{H}_3\text{PO}_4 + 3 \text{Ba(OH)}_2 \rightarrow 6 \text{H}_2\text{O} + \text{Ba}_3(\text{PO}_4)_2 \)
(e) \( \text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{H}_2\text{O} + \text{NaCH}_3\text{COO} \)
(f) \( 2 \text{HNO}_3 + \text{Sr(OH)}_2 \rightarrow 2 \text{H}_2\text{O} + \text{Sr(NO}_3)_2 \)
(g) \( 3 \text{HF} + \text{Fe(OH)}_3 \rightarrow 3 \text{H}_2\text{O} + \text{FeF}_3 \)
(h) \( 4 \text{HBr} + \text{Sn(OH)}_4 \rightarrow 4 \text{H}_2\text{O} + \text{SnBr}_4 \)
2. (a) sulphuric acid + potassium hydroxide \( \rightarrow \)
   \( \text{water} + \text{potassium sulphate} \)
   \( \text{H}_2\text{SO}_4 + 2 \text{KOH} \rightarrow 2 \text{H}_2\text{O} + \text{K}_2\text{SO}_4 \)

(b) acetic acid + barium hydroxide \( \rightarrow \)
   \( \text{water} + \text{barium acetate} \)
   \( 2 \text{CH}_3\text{COOH} + \text{Ba(OH)}_2 \rightarrow 2 \text{H}_2\text{O} + \text{Ba(CH}_3\text{COO)}_2 \)
(c) phosphoric acid + aluminum hydroxide \( \rightarrow \)
   \( \text{water} + \text{aluminum phosphate} \)
   \( \text{H}_3\text{PO}_4 + \text{Al(OH)}_3 \rightarrow 3 \text{H}_2\text{O} + \text{AlPO}_4 \)
(d) nitric acid + lithium hydroxide \( \rightarrow \)
   \( \text{water} + \text{lithium nitrate} \)
   \( \text{HNO}_3 + \text{LiOH} \rightarrow \text{H}_2\text{O} + \text{LiNO}_3 \)
(e) sulphuric acid + calcium hydroxide \( \rightarrow \)
   \( \text{water} + \text{calcium sulphate} \)
   \( \text{H}_2\text{SO}_4 + \text{Ca(OH)}_2 \rightarrow 2 \text{H}_2\text{O} + \text{CaSO}_4 \)
(f) hydrochloric acid + magnesium hydroxide \( \rightarrow \)
   \( \text{water} + \text{magnesium chloride} \)
   \( 2 \text{HCl} + \text{Mg(OH)}_2 \rightarrow 2 \text{H}_2\text{O} + \text{MgCl}_2 \)

Applying Knowledge
Metal oxides and non-metal oxides
Page 93
1. oxygen
2. metal oxide
3. non-metal oxide
4. it becomes basic
5. it becomes acidic
6. a base
7. an acid
8. (a) metal oxide
   (b) non-metal oxide
   (c) non-metal oxide
   (d) metal oxide
   (e) non-metal oxide
   (f) metal oxide
   (g) non-metal oxide
   (h) metal oxide
9. (a) a base
   (b) an acid
   (c) a base
   (d) an acid

Assessment
Salts
Page 94
Section 5.3 Organic Compounds

Cloze Activity
Organic chemistry
Page 98
1. organic compounds; organic chemistry
2. inorganic compounds
3. carbon
4. hydrocarbons
5. methane
6. ethane
7. propane
8. butane
9. alcohol; oxygen
10. solvent
11. ethanol

Comprehension
Recognizing organic and inorganic compounds
Page 99
1. inorganic
2. organic
3. inorganic
4. inorganic
5. inorganic
6. inorganic
7. organic
8. organic
9. organic
10. organic
11. inorganic
12. inorganic
13. organic
14. inorganic
15. organic
16. organic
17. inorganic
18. organic
19. inorganic
20. inorganic
21. inorganic
22. inorganic
23. organic
24. inorganic
25. organic
26. organic
27. organic
28. organic
29. organic
30. organic

Applying Knowledge
Organic compounds versus inorganic compounds
Page 100
1. organic
2. organic
3. inorganic
4. organic
5. organic
6. organic
7. inorganic
8. organic

Assessment
Organic compounds
Page 101

Chapter 6 Chemical reactions occur in predictable ways.
Section 6.1 Types of Chemical Reactions

Comprehension
Classifying chemical reactions
Page 105
1. S
   \[ \text{N}_2 + 3 \text{F}_2 \rightarrow 2 \text{NF}_3 \]
2. D
   \[ 2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2 \]
3. C
   \[ \text{C}_12\text{H}_{22}\text{O}_{11} + 12 \text{O}_2 \rightarrow 12 \text{CO}_2 + 11 \text{H}_2\text{O} \]
4. SR
   \[ 3 \text{CuSO}_4 + 2 \text{Fe} \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 3 \text{Cu} \]
5. DR
   \[ \text{MgF}_2 + \text{Li}_2\text{CO}_3 \rightarrow \text{MgCO}_3 + 2 \text{LiF} \]
6. N
   \[ \text{H}_3\text{PO}_4 + 3 \text{NH}_3\text{OH} \rightarrow 3 \text{H}_2\text{O} + (\text{NH}_4)_3\text{PO}_4 \]
7. SR
   \[ 2 \text{NaF} + \text{Br}_2 \rightarrow 2 \text{NaBr} + \text{F}_2 \]
8. C
   \[ 2 \text{CH}_3\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 4 \text{H}_2\text{O} \]
9. D
   \[ \text{ZnCl}_2 \rightarrow \text{Zn} + \text{Cl}_2 \]
10. DR
    \[ 2 \text{RbNO}_3 + \text{BeF}_2 \rightarrow \text{Be(NO}_3)_2 + 2 \text{RbF} \]
11. S
\[ S_8 + 8 \text{H}_2 \rightarrow 8 \text{H}_2\text{S} \]

12. SR
\[ 2 \text{LiCl} + \text{Br}_2 \rightarrow 2 \text{LiBr} + \text{Cl}_2 \]

13. N
\[ \text{H}_2\text{SO}_4 + 2 \text{KOH} \rightarrow 2 \text{H}_2\text{O} + \text{K}_2\text{SO}_4 \]

14. C
\[ \text{C}_{10}\text{H}_8 + 12 \text{O}_2 \rightarrow 10 \text{CO}_2 + 4 \text{H}_2\text{O} \]

15. D
\[ 2 \text{HI} \rightarrow \text{H}_2 + \text{I}_2 \]

16. SR
\[ 6 \text{HCl} + 2 \text{Al} \rightarrow 3 \text{H}_2 + 2 \text{AlCl}_3 \]

17. S
\[ 2 \text{P} + 3 \text{Cl}_2 \rightarrow 2 \text{PCl}_3 \]

18. C
\[ 2 \text{C}_5\text{H}_12 + 15 \text{O}_2 \rightarrow 5 \text{CO}_2 + 6 \text{H}_2\text{O} \]

19. DR
\[ \text{K}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow \text{BaSO}_4 + 2 \text{KCl} \]

20. N
\[ 3 \text{HCl} + \text{Al(OH)}_3 \rightarrow \text{AlCl}_3 + 3 \text{H}_2\text{O} \]

21. S
\[ \text{NH}_3\text{PO}_4 + 2 \text{NaOH} \rightarrow 2 \text{H}_2\text{O} + \text{Na}_2\text{PO}_4 \]

22. SR
\[ \text{GaF}_3 + 3 \text{Cs} \rightarrow 3 \text{CsF} + \text{Ga} \]

23. N
\[ \text{HCl} + \text{Al(OH)}_3 \rightarrow \text{AlCl}_3 + 3 \text{H}_2\text{O} \]

24. C
\[ \text{C}_5\text{H}_12 + 8 \text{O}_2 \rightarrow 5 \text{CO}_2 + 6 \text{H}_2\text{O} \]

25. DR
\[ \text{Ca(NO)}_3\text{H} + 2 \text{NaClO}_4 \rightarrow 2 \text{NaNO}_3 + \text{CaCl}_2 \]

26. N
\[ \text{Ca(NO)}_3\text{H} + 2 \text{NaClO}_4 \rightarrow 2 \text{NaNO}_3 + \text{CaCl}_2 \]

27. S
\[ \text{MgS} + \text{S} \rightarrow \text{MgS}_2 \]

Applying Knowledge
Types of chemical reactions — Word equations
Page 107

1. S
\[ \text{MgS} + \text{S} \rightarrow \text{MgS}_2 \]

2. N
\[ 2 \text{KOH} + \text{H}_2\text{SO}_4 \rightarrow 2 \text{H}_2\text{O} + \text{K}_2\text{SO}_4 \]

3. SR
\[ \text{Cl}_2 + 2 \text{KI} \rightarrow 2 \text{KCl} + \text{I}_2 \]

4. DR
\[ \text{AlCl}_3 + 3 \text{NaOH} \rightarrow \text{Al(OH)}_3 + 3 \text{NaCl} \]

5. D
\[ 2 \text{Pb} \rightarrow 2 \text{Pb} + \text{O}_2 \]

6. SR
\[ \text{Mg} + 2 \text{AgNO}_3 \rightarrow 2 \text{Ag} + \text{Mg(NO)}_3\text{H}_2 \]

7. DR
\[ \text{Cd(NO)}_3\text{H} + (\text{NH}_3\text{)}_2\text{S} \rightarrow \text{CdS} + 2 \text{NH}_4\text{NO}_3 \]

8. N
\[ \text{Sn(OH)}_4 + 4 \text{HBr} \rightarrow 4 \text{H}_2\text{O} + \text{SnBr}_4 \]

9. S
\[ 4 \text{Na} + \text{O}_2 \rightarrow 2 \text{Na}_2\text{O} \]

10. D
\[ 2 \text{Na}_2\text{N} \rightarrow 6 \text{Na} + \text{N}_2 \]

11. N
\[ 2 \text{Na}_2\text{S} + 2 \text{H}_2\text{O} \rightarrow 2 \text{Na}_2\text{SO}_4 + 2 \text{H}_2 \]

12. DR
\[ \text{BaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{BaCO}_3 + 2 \text{NaCl} \]

13. SR
\[ \text{Zn} + \text{Ni(NO)}_3\text{H}_2 \rightarrow \text{Zn(NO)}_3\text{H}_2 + \text{Ni} \]

14. S
\[ 2 \text{Sb} + 3 \text{I}_2 \rightarrow 2 \text{SbI}_3 \]

15. D
\[ \text{CO}_2 \rightarrow \text{C} + \text{O}_2 \]

16. SR
\[ \text{Fe}_3\text{(SO)}_4\text{H}_3 + 3 \text{Pb} \rightarrow 3 \text{PbSO}_4 + 2 \text{Fe} \]

17. DR
\[ \text{Ba(NO)}_3\text{H} + (\text{NH}_3\text{)}_2\text{CO}_3 \rightarrow 2 \text{NH}_4\text{NO}_3 + \text{BaCO}_3 \]

18. N
\[ \text{Zn(OH)}_2 + 2 \text{HCl} \rightarrow 2 \text{H}_2\text{O} + \text{ZnCl}_2 \]

19. DR
\[ (\text{NH}_3\text{)}_2\text{CO}_3 + \text{MgCl}_2 \rightarrow 2 \text{NH}_3\text{Cl} + \text{MgCO}_3 \]

20. N
\[ 2 \text{RbOH} + \text{H}_2\text{SO}_4 \rightarrow 2 \text{H}_2\text{O} + \text{Rb}_2\text{SO}_4 \]

Applying Knowledge
Predicting the products
Page 109

1. (a) D
\[ 2 \text{H}_2\text{O} \rightarrow 2 \text{H}_2 + \text{O}_2 \]

(b) S
\[ \text{H}_2 + \text{Cl}_2 \rightarrow 2 \text{HCl} \]
(c) SR
2 NaI + F₂ → 2 NaF + I₂

(d) DR
3 AgNO₃ + Na₃PO₄ → Ag₃PO₄ + 3 NaNO₃

(e) N
Ba(OH)₂ + H₂SO₄ → BaSO₄ + 2 H₂O

(f) S
P₄ + 6 Cl₂ → 4 PCl₃

(g) C
2 CH₃OH + 3 O₂ → 2 CO₂ + 4 H₂O

(h) N
3 Sr(OH)₂ + 2 H₃PO₄ → Sr₃(PO₄)₂ + 6 H₂O

(i) D
FeI₂ → Fe + I₂

(j) SR
CuCl₂ + Fe → FeCl₂ + Cu

(k) DR
Cr₂(SO₄)₃ + 3 K₂CO₃ → Cr₂(CO₃)₃ + 3 K₂SO₄

(l) C
C₂H₅OH + 3 O₂ → 2 CO₂ + 3 H₂O

2. (a) S
sodium + chlorine → sodium chloride
2 Na + Cl₂ → 2 NaCl

(b) SR
gallium fluoride + cesium → cesium fluoride + gallium
GaF₃ + 3 Cs → 3 CsF + Ga

(c) N
calcium hydroxide + nitric acid → calcium nitrate + water
Ca(OH)₂ + 2 HNO₃ → Ca(NO₃)₂ + 2 H₂O

(d) DR
barium chloride + silver nitrate → barium nitrate + silver chloride
BaCl₂ + 2 AgNO₃ → Ba(NO₃)₂ + 2 AgCl

(e) D
cobalt(II) iodide → cobalt + bromine
CoBr₂ → Co + Br₂

(f) SR
copper(II) iodide + bromine → copper(II) bromide + iodine
CuI₂ + Br₂ → CuBr₂ + I₂

(g) N
phosphoric acid + magnesium hydroxide → magnesium phosphate + water
2 H₃PO₄ + 3 Mg(OH)₂ → Mg₃(PO₄)₂ + 6 H₂O

(h) S
zinc + iodine → zinc iodide
Zn + I₂ → ZnI₂

(i) D
beryllium chloride → beryllium + chlorine
BeCl₂ → Be + Cl₂

(j) DR
iron(III) sulphate + calcium hydroxide → iron(III) hydroxide + calcium sulphate
Fe₂(SO₄)₃ + 3 Ca(OH)₂ → 2 Fe(OH)₃ + 3 CaSO₄

Assessment
Types of chemical reactions
Page 111

Section 6.2 Factors Affecting the Rate of Chemical Reactions

Cloze Activity
Rate of chemical reactions
Page 115
1. rate of reaction
2. heat; energy
3. temperature
4. concentration; collisions
5. dilute
6. surface area
7. catalyst
8. catalytic converter

Comprehension
Different rates of reaction
Page 116
1. (a) increases rate of reaction
(b) decreases rate of reaction
(c) increases rate of reaction
(d) decreases rate of reaction
(e) decreases rate of reaction
Chapter 7 The atomic theory explains radioactivity.

Section 7.1 Atomic Theory Isotopes, and Radioactive Decay

Applying Knowledge
Isotopes
Page 123

1. different atoms of a particular element that have the same number of protons but different numbers of neutrons
2. mass number
3. mass number
4. number of neutrons
5. “13” represents the mass number; “5” represents the atomic number
6. boron-13 or B-13
7. (a) 5
   (b) 5
   (c) 8
8. (a) neon with 11 neutrons
   (b) sulphur with 16 neutrons
   (c) actinium with 141 neutrons
   (d) thorium with 144 neutrons
9.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Standard atomic notation</th>
<th>Atomic number</th>
<th>Mass number</th>
<th>Number of protons</th>
<th>Number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon-14</td>
<td>$^{14}_{6}\text{C}$</td>
<td>6</td>
<td>14</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>cobalt-52</td>
<td>$^{52}_{27}\text{Co}$</td>
<td>27</td>
<td>52</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>nickel-60</td>
<td>$^{60}_{28}\text{Ni}$</td>
<td>28</td>
<td>60</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>nitrogen-14</td>
<td>$^{14}_{7}\text{N}$</td>
<td>7</td>
<td>14</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>thallium-201</td>
<td>$^{201}_{81}\text{Tl}$</td>
<td>81</td>
<td>201</td>
<td>81</td>
<td>120</td>
</tr>
<tr>
<td>radium-226</td>
<td>$^{226}_{88}\text{Ra}$</td>
<td>88</td>
<td>226</td>
<td>88</td>
<td>138</td>
</tr>
<tr>
<td>lead-208</td>
<td>$^{208}_{82}\text{Pb}$</td>
<td>82</td>
<td>208</td>
<td>82</td>
<td>126</td>
</tr>
</tbody>
</table>

Comprehension
Alpha, beta, and gamma radiation
Page 125

1. diagram labelling: alpha particle (on the first line); beta particle (on the second line); gamma ray (on the third line)
2. (a) gamma ray
   (b) beta particle
   (c) alpha particle
   (d) gamma ray
Applying Knowledge
Radioactive decay and nuclear equations
Page 126

1. \( ^{32}_{15} \text{P} \rightarrow ^{32}_{16} \text{S} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

2. \( ^{218}_{84} \text{Po} \rightarrow ^{214}_{82} \text{He} + ^{4}_{2} \text{ALPHA DECAY} \)

3. \( ^{35}_{17} \text{Cl} \rightarrow ^{35}_{18} \text{Ar} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

4. \( ^{24}_{12} \text{Mg}^* \rightarrow ^{24}_{12} \text{Mg} + ^{0}_{0} \gamma + ^{0}_{0} \text{GAMMA DECAY} \)

5. \( ^{234}_{91} \text{Pa} \rightarrow ^{230}_{89} \alpha + ^{4}_{2} \text{ALPHA DECAY} \)

6. \( ^{141}_{58} \text{Ce} \rightarrow ^{141}_{57} \text{Pr} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

7. \( ^{216}_{84} \text{Po} \rightarrow ^{216}_{83} \text{At} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

8. \( ^{20}_{8} \text{F} \rightarrow ^{20}_{10} \text{Ne} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

9. \( ^{58}_{26} \text{Fe}^* \rightarrow ^{58}_{26} \text{Fe} + ^{0}_{0} \gamma + ^{0}_{0} \text{GAMMA DECAY} \)

10. \( ^{225}_{89} \text{Ac} \rightarrow ^{227}_{87} \text{Fr} + ^{4}_{2} \text{ALPHA DECAY} \)

11. \( ^{149}_{64} \text{Gd}^* \rightarrow ^{149}_{65} \text{Gd} + ^{0}_{0} \gamma + ^{0}_{0} \text{GAMMA DECAY} \)

12. \( ^{228}_{86} \text{Ra} \rightarrow ^{222}_{88} \text{Rn} + ^{4}_{2} \text{ALPHA DECAY} \)

13. \( ^{212}_{81} \text{TI} \rightarrow ^{212}_{82} \text{Pb} + ^{0}_{-1} \beta + ^{0}_{-1} \text{BETA DECAY} \)

14. \( ^{214}_{83} \text{Bi} \rightarrow ^{210}_{81} \text{Po} + ^{4}_{2} \text{ALPHA DECAY} \)

15. \( ^{254}_{98} \text{Cf}^* \rightarrow ^{254}_{98} \text{Cf} + ^{0}_{0} \gamma + ^{0}_{0} \text{GAMMA DECAY} \)

Assessment
Atomic theory, isotopes, and radioactive decay
Page 127


Section 7.2 Half-Life
Applying Knowledge
Radioactive decay
Page 132

1. (a) the time required for half the nuclei in a sample of a radioactive isotope to decay; a constant for any radioactive isotope

(b) a curved line on a graph that shows the rate at which radioisotopes decay

(c) the isotope that undergoes radioactive decay

(d) the stable product of radioactive decay

2.

<table>
<thead>
<tr>
<th>Half-life</th>
<th>Percent of parent isotope</th>
<th>Percent of daughter isotope</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>12.5</td>
<td>87.5</td>
</tr>
<tr>
<td>4</td>
<td>6.25</td>
<td>93.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Half-life</th>
<th>Fraction of parent isotope</th>
<th>Fraction of daughter isotope</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>3</td>
<td>0.125</td>
<td>0.875</td>
</tr>
<tr>
<td>4</td>
<td>0.0625</td>
<td>0.9375</td>
</tr>
</tbody>
</table>

3. (a)

<table>
<thead>
<tr>
<th>Half-life</th>
<th>Time (a)</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>3.75</td>
</tr>
</tbody>
</table>

(b) 3.75 g

(c) 3 half-lives

(d) 20 years

(e) The graph should show a decay curve.
4. (a)  
(b) 5 g  
(c) 2.5 g  
(d) 70 g  
(e) 100 years  
(f) 1:3

Comprehension  
Calculating half-life  
Page 134  
1. (a) $\frac{1}{8}$  
(b) 6.25%  
(c) $\frac{3}{4}$  
(d) 96.875%  
2. 18 g  
3. 12.5%  
4. 48 g  
5. 1420 million years old  
6. 3.9 billion years old  
7. 9 billion years  
8. 5 years  
9. 10 g  

Analyzing Information  
Decay curves  
Page 135  
1. (a) 2 days  
(b) 20 g  
(c) 70 g  
(d) $\frac{1}{16}$  
(e) 8 days  
2. (a) potassium-40 and argon-40  
(b) 1.3 billion years  
(c) equal amounts of daughter and parent isotopes  
(d) $\frac{15}{16}$  
(e) 1:3

Section 7.3 Nuclear Reactions  
Cloze Activity  
Radioactivity  
Page 140  
1. nuclear fission  
2. unstable  
3. energy  
4. nuclear reaction; isotope  
5. subatomic particles  
6. induced  
7. proton  
8. neutron  
9. chain reaction  
10. CANDU reactor  
11. nuclear fusion; Sun  

Comprehension  
Comparing nuclear fission and fusion  
Page 141  
1.  

<table>
<thead>
<tr>
<th>Nuclear fission</th>
<th>Nuclear fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give a description of the process.</td>
<td>one heavy unstable nucleus splits up into lighter nuclei</td>
</tr>
<tr>
<td>What is produced as a result of this nuclear process?</td>
<td>huge amounts of energy; neutrons; radioactive isotopes</td>
</tr>
<tr>
<td>Are the products radioactive?</td>
<td>two small nuclei combine to form one large nucleus</td>
</tr>
<tr>
<td>What is needed for this nuclear reaction to occur?</td>
<td>huge amounts of energy; neutron(s)</td>
</tr>
<tr>
<td>Where does this process occur?</td>
<td>products are often radioactive</td>
</tr>
<tr>
<td>Give an example of a nuclear equation.</td>
<td>products are not often radioactive</td>
</tr>
</tbody>
</table>

1. $\frac{1}{n} \text{n} + \frac{235}{92} \text{U} \rightarrow \frac{92}{36} \text{Kr} + \frac{141}{56} \text{Ba} + 3\frac{1}{0} \text{n} + \text{energy}$
UNIT 3 Motion

Chapter 8 Average velocity is the rate of change in position.

Section 8.1 The Language of Motion

Comprehension

 Scalars versus vectors

Page 147

1. (a) scalar: a quantity that has a magnitude but not a direction

   (b) vector: a quantity that has both a magnitude and a direction

   (c) magnitude: the size of a measurement or an amount

   (d) reference point: the point from which the change is measured

2.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Symbol</th>
<th>SI Unit</th>
<th>Scalar or Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>( t )</td>
<td>s (seconds)</td>
<td>scalar</td>
</tr>
<tr>
<td>time interval</td>
<td>( \Delta t )</td>
<td>s (seconds)</td>
<td>scalar</td>
</tr>
<tr>
<td>distance</td>
<td>( d )</td>
<td>m (metres)</td>
<td>scalar</td>
</tr>
<tr>
<td>position</td>
<td>( \vec{d} )</td>
<td>m (metres)</td>
<td>vector</td>
</tr>
<tr>
<td>displacement</td>
<td>( \Delta \vec{d} )</td>
<td>m (metres)</td>
<td>vector</td>
</tr>
</tbody>
</table>

3. (a) V (b) S (c) S (d) V

4. (a) positive (+)

   (b) negative (–)

   (c) positive (+)

   (d) negative (–)

Applying Knowledge

Distance, position, and displacement

Page 148

1.

<table>
<thead>
<tr>
<th>( t_i ) (s)</th>
<th>( t_f ) (s)</th>
<th>( \Delta t ) (s)</th>
<th>( d_i ) (m)</th>
<th>( d_f ) (m)</th>
<th>( \Delta d ) (m)</th>
<th>Direction of Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>7.5</td>
<td>1.5</td>
<td>+18.4</td>
<td>+22.6</td>
<td>+4.2</td>
<td>right</td>
</tr>
<tr>
<td>5.7</td>
<td>8.5</td>
<td>2.8</td>
<td>+24.3</td>
<td>+30.1</td>
<td>+5.8</td>
<td>up</td>
</tr>
<tr>
<td>20.2</td>
<td>38.4</td>
<td>18.2</td>
<td>+39.1</td>
<td>+24.8</td>
<td>-14.3</td>
<td>south</td>
</tr>
<tr>
<td>12.4</td>
<td>18.8</td>
<td>6.4</td>
<td>+54.8</td>
<td>+46.2</td>
<td>-8.6</td>
<td>west</td>
</tr>
</tbody>
</table>

2. (a) 12 m

   (b) 0 m

3. (a)

<table>
<thead>
<tr>
<th>Time</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 min</td>
<td>0 m</td>
</tr>
<tr>
<td>1 min</td>
<td>180 m [E]</td>
</tr>
<tr>
<td>2 min</td>
<td>40 m [E]</td>
</tr>
<tr>
<td>3 min</td>
<td>140 m [E]</td>
</tr>
</tbody>
</table>
Section 8.2 Applying Knowledge

Applying Knowledge
Calculating average velocity
Page 156
1. (a) \( v_{av} = \frac{\Delta d}{\Delta t} \)

2. \( \Delta t = \frac{\Delta d}{v_{av}} \)

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Time</th>
<th>Average Velocity</th>
<th>Formula Used and Calculation Shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.6 m</td>
<td>3 s</td>
<td>5.2 m/s</td>
<td>( \bar{v}_{av} = \frac{15.6}{3} = 5.2 \text{ m/s} )</td>
</tr>
<tr>
<td>357.5 km</td>
<td>6.5 h</td>
<td>55 km/h</td>
<td>( \bar{v}_{av} = \frac{357.5}{6.5} = 55 \text{ km/h} )</td>
</tr>
<tr>
<td>22.6 m</td>
<td>4 s</td>
<td>5.65 m/s</td>
<td>( \Delta t = \frac{22.6}{5.65} = 4 \text{ s} )</td>
</tr>
<tr>
<td>243.75 km</td>
<td>3.25 h</td>
<td>75 km/h</td>
<td>( \Delta t = \frac{243.75}{75} = 3.25 \text{ h} )</td>
</tr>
<tr>
<td>12.6 m</td>
<td>3.15 s</td>
<td>4 m/s</td>
<td>( \bar{v}_{av} = \frac{12.6}{3.15} = 4 \text{ m/s} )</td>
</tr>
<tr>
<td>24 km</td>
<td>0.75 h</td>
<td>32 km/h</td>
<td>( \Delta t = \frac{24}{32} = 0.75 \text{ h} )</td>
</tr>
<tr>
<td>480 m</td>
<td>8 s</td>
<td>60 m/s</td>
<td>( \Delta t = \frac{480}{60} = 8 \text{ s} )</td>
</tr>
</tbody>
</table>

3. (a) 150 s
(b) 70 s
(c) 255 m [E]
(d) 14 s
(e) 0.375 km/min
(f) 800 000 a (years)
(g) 0.65 km, or 650 m

Applying Knowledge
Slopes of position-time graphs
Page 157
1. average velocity
2. uniform motion; constant velocity
3. Slope is the change in the vertical distance divided by the change in the horizontal distance.
4. \( \text{slope} = \frac{\text{rise}}{\text{run}} \)
5.

<table>
<thead>
<tr>
<th>Line</th>
<th>Rise</th>
<th>Run</th>
<th>Slope Calculation</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>15</td>
<td>4 ÷ 15</td>
<td>0.27 m/s</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>20</td>
<td>0 ÷ 20</td>
<td>0 m/s</td>
</tr>
<tr>
<td>C</td>
<td>8</td>
<td>5</td>
<td>8 ÷ 5</td>
<td>1.6 m/s</td>
</tr>
<tr>
<td>D</td>
<td>−6</td>
<td>15</td>
<td>−6 ÷ 15</td>
<td>−0.4 m/s</td>
</tr>
</tbody>
</table>
Analyzing Information
Analyzing position-time graphs
Page 158

1. (a)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Displacement</th>
<th>Average Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 s–2 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>2 s–5 s</td>
<td>–3 m</td>
<td>–1 m/s</td>
</tr>
<tr>
<td>5 s–7 s</td>
<td>+5 m</td>
<td>+2.5 m/s</td>
</tr>
<tr>
<td>7 s–12 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>12 s–14 s</td>
<td>–8 m</td>
<td>–4 m/s</td>
</tr>
<tr>
<td>14 s–16 s</td>
<td>+4 m</td>
<td>+2 m/s</td>
</tr>
<tr>
<td>16 s–18 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>18 s–19 s</td>
<td>+2 m</td>
<td>+2 m/s</td>
</tr>
<tr>
<td>19 s–20 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
</tbody>
</table>

(b) at 14 seconds
(c) 0 m

2. (a) C
(b) E
(c) B
(d) D
(e) F
(f) A

3. (a) The y-intercept represents the position at which the runner starts.
(b) No. Runner B starts out farther ahead than Runner A.
(c) Runner B is running faster at 2 s because Runner B has a steeper slope than Runner A.
(d) At 5 s, both runners are at the same position.
(e) Runner A is ahead at 10 s.

Extension Activity
Constructing and interpreting position-time graphs
Page 160

1. (a) Graph should have a negative slope crossing the x-axis at 5 s.
(b) 3 seconds
(c) 100 m [E]
(d) –12.5 m [W]
(e) –25 m/s
(f) The car is moving westward toward the origin with constant velocity.

2. (a)

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Displacement</th>
<th>Average Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 s–2 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>2 s–5 s</td>
<td>–3 m</td>
<td>–1 m/s</td>
</tr>
<tr>
<td>5 s–7 s</td>
<td>+5 m</td>
<td>+2.5 m/s</td>
</tr>
<tr>
<td>7 s–12 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>12 s–14 s</td>
<td>–8 m</td>
<td>–4 m/s</td>
</tr>
<tr>
<td>14 s–16 s</td>
<td>+4 m</td>
<td>+2 m/s</td>
</tr>
<tr>
<td>16 s–18 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
<tr>
<td>18 s–19 s</td>
<td>+2 m</td>
<td>+2 m/s</td>
</tr>
<tr>
<td>19 s–20 s</td>
<td>0 m</td>
<td>0 m/s</td>
</tr>
</tbody>
</table>

(b) at 14 seconds
(c) 0 m

2. (a) C
(b) E
(c) B
(d) D
(e) F
(f) A

3. (a) The y-intercept represents the position at which the runner starts.
(b) No. Runner B starts out farther ahead than Runner A.
(c) Runner B is running faster at 2 s because Runner B has a steeper slope than Runner A.
(d) At 5 s, both runners are at the same position.
(e) Runner A is ahead at 10 s.

Assessment
Average velocity
Page 162


Chapter 9 Acceleration is the rate of change in velocity.

Section 9.1 Describing Acceleration

Cloze Activity
Velocity and acceleration
Page 166

1. vector, speed
2. positive
3. negative
Applying Knowledge

Calculating change in velocity

Page 167

1. \[ \Delta \vec{v} = \frac{\Delta v}{\Delta t} \]

<table>
<thead>
<tr>
<th>( \Delta v )</th>
<th>Time</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9 m/s</td>
<td>8 s</td>
<td>+17.5 m/s²</td>
</tr>
<tr>
<td>0 m/s</td>
<td>4 h</td>
<td>+15 km/h²</td>
</tr>
<tr>
<td>+12 m/s</td>
<td>2.5 h</td>
<td>+48 km/h²</td>
</tr>
<tr>
<td>-50 m/s</td>
<td>15 s</td>
<td>-3.5 m/s²</td>
</tr>
<tr>
<td>-10 m/s</td>
<td>2.5 s</td>
<td>+4.8 m/s²</td>
</tr>
<tr>
<td>0 m/s</td>
<td>9.6 h</td>
<td>+5 km/h²</td>
</tr>
</tbody>
</table>

2. (a) +15 m/s
   (b) +13 m/s
   (c) 0 m/s
   (d) -6 m/s
   (e) -10 m/s

Interpreting Illustrations

Positive, negative, and zero acceleration

Page 168

1. (a) positive acceleration
   (b) zero acceleration
   (c) negative acceleration
   (d) zero acceleration

2. (a) positive acceleration
   (b) negative acceleration
   (c) positive acceleration
   (d) negative acceleration
   (e) zero acceleration
   (f) positive acceleration

Assessment

Describing acceleration

Page 169


Section 9.2 Calculating Acceleration

Applying Knowledge

Calculating acceleration

Page 172

1. (a) \[ \Delta \vec{a} = \frac{\Delta \vec{v}}{\Delta t} \]
   (b) \[ \vec{a} = \frac{\Delta \vec{v}}{\Delta t} \]
   (c) \[ \Delta t = \frac{\Delta \vec{v}}{\vec{a}} \]

2. 

<table>
<thead>
<tr>
<th>Change in Velocity</th>
<th>Time</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>140 m/s</td>
<td>8 s</td>
<td>+17.5 m/s²</td>
</tr>
<tr>
<td>-60 km/h</td>
<td>4 h</td>
<td>-15 km/h²</td>
</tr>
<tr>
<td>120 km/h</td>
<td>2.5 h</td>
<td>+48 km/h²</td>
</tr>
<tr>
<td>-52.5 m/s</td>
<td>15 s</td>
<td>-3.5 m/s²</td>
</tr>
<tr>
<td>12 m/s</td>
<td>2.5 s</td>
<td>+4.8 m/s²</td>
</tr>
<tr>
<td>-25 m/s</td>
<td>2 s</td>
<td>-12.5 m/s²</td>
</tr>
<tr>
<td>48 km/h</td>
<td>9.6 h</td>
<td>+5 km/h²</td>
</tr>
</tbody>
</table>

3. (a) 7.8 m/s² [north]
   (b) 6 m/s [forward]
   (c) 1.52 s
   (d) +1700 m/s

Analyzing Information

Analyzing velocity-time graphs

Page 173

1. (a) acceleration
   (b) positive velocity
   (c) negative velocity
   (d) positive acceleration
   (e) negative acceleration
   (f) constant velocity; zero acceleration
   (g) zero velocity

2. 

<table>
<thead>
<tr>
<th>MOTION OF A BALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Interval</td>
</tr>
<tr>
<td>0 s – 2 s</td>
</tr>
<tr>
<td>2 s – 6 s</td>
</tr>
<tr>
<td>6 s – 8 s</td>
</tr>
<tr>
<td>8 s – 10 s</td>
</tr>
</tbody>
</table>

3. (a) ball starts from rest and increases its velocity at a constant rate, heading to the right
   (b) ball travels right at a constant velocity and has zero acceleration

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(c) ball slows down to a stop at a constant rate, while still travelling to the right
(d) ball is at rest (it has stopped)

Illustrating Concepts
Sketching and interpreting velocity-time graphs
Page 174

1.

<table>
<thead>
<tr>
<th>Slope</th>
<th>Graph A</th>
<th>Graph B</th>
<th>Graph C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration</td>
<td>zero acceleration</td>
<td>positive acceleration</td>
<td>negative acceleration</td>
</tr>
</tbody>
</table>

2.

<table>
<thead>
<tr>
<th>Positive Velocity</th>
<th>Positive Acceleration</th>
<th>Negative Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>Time</td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Velocity</td>
<td>Time</td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. (a)

(b) (i) zero slope
(ii) positive slope
(iii) zero slope
(iv) negative slope
(v) zero slope

(c) (i) zero acceleration
(ii) positive acceleration
(iii) zero acceleration
(iv) negative acceleration
(v) zero acceleration

Assessment
Calculating acceleration
Page 176

UNIT 4 Energy Transfer in Natural Systems
Chapter 10 The kinetic molecular theory explains the transfer of thermal energy.

Section 10.1 Temperature, Thermal Energy, and Heat

Illustrating concepts
Kinetic molecular theory and temperature
Page 180

1. Kinetic energy is the energy of a particle or object due to its motion.

2.

<table>
<thead>
<tr>
<th></th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>spaces between particles</td>
<td>very close</td>
<td>farther apart</td>
<td>even farther apart</td>
</tr>
<tr>
<td>movement of particles</td>
<td>vibrate slowly</td>
<td>move faster</td>
<td>move even faster</td>
</tr>
<tr>
<td>kinetic energy of particles</td>
<td>very little</td>
<td>increases</td>
<td>increases as collisions increase</td>
</tr>
</tbody>
</table>

3. Temperature is a measure of the average kinetic energy of all the particles in a sample of matter.

4. Hot water: Drawing should show long arrows (see textbook page 425, figure 10.2).
Cold water: Drawing should show shorter arrows (see textbook page 425, figure 10.2).

5.

<table>
<thead>
<tr>
<th></th>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Kelvin</th>
</tr>
</thead>
<tbody>
<tr>
<td>absolute zero</td>
<td>−459°F</td>
<td>−273°C</td>
<td>0 K</td>
</tr>
<tr>
<td>water freezes</td>
<td>32°F</td>
<td>0°C</td>
<td>273 K</td>
</tr>
<tr>
<td>water boils</td>
<td>212°F</td>
<td>100°C</td>
<td>373 K</td>
</tr>
</tbody>
</table>

Comprehension
Thermal energy, kinetic energy, potential energy
Page 181

1. Thermal energy is the total energy of all the particles in a solid, liquid, or gas.
2. Kinetic energy is the energy of a particle or an object due to its motion.
3. Potential energy is the stored energy of an object or particle, due to its position or state.
4. As the temperature of an object rises, the amount of thermal energy rises.
5. As the kinetic energy of a group of molecules increases, the molecules move faster.
6. As the potential energy of a group of molecules increases, the molecules move farther apart.
7. Heat is the amount of thermal energy that transfers from an area or object of high temperature to an area or object of low temperature.
8. Answers may vary. Concept should show initial thermal energy having high levels then transferring this energy to an area or object with low thermal energy. End result of the transfer of energy would be increase in molecules moving and temperature then rising.
9. Thermal energy is transferred by conduction, convection, and radiation.

Applying Knowledge
Thermal energy transfer
Page 182

1. Metals are good thermal conductors.
2. Air, snow, wood, and Styrofoam are materials that do not transfer thermal energy easily and are called insulators.
3. Heating the liquid causes the particles to move faster. The warmer liquid moves to the top of the lamp because it is less dense than the surrounding liquid. At the top of the lamp, the liquid cools, contracts, and sinks only to be reheated and recirculated. The lava lamp operates by a convection current.
4. Radiant energy is the energy carried by electromagnetic waves.

Assessment
Temperature, thermal energy, and heat
Page 183

Section 10.2 Energy Transfer in the Atmosphere

Applying Knowledge
The Earth’s atmosphere
Page 188
1. Air is a combination of gases in the lower atmosphere.
2. Nitrogen and oxygen make up 99 percent of dry air.
3. The Earth’s rotation, the effects of day and night, and the Sun are some of the factors that cause the atmosphere to constantly change.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Altitude above sea level</th>
<th>Average temperature</th>
<th>Factors affecting composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>troposphere</td>
<td>10 km</td>
<td>Drops 6.5°C per 1 km increase</td>
<td>• water vapour • solar radiation • thermal energy • particulate matter</td>
</tr>
<tr>
<td>stratosphere</td>
<td>10–50 km</td>
<td>–55°C</td>
<td>• clear dry air • warmer at top • winds • ozone layer</td>
</tr>
<tr>
<td>mesosphere</td>
<td>50–80 km</td>
<td>–100°C</td>
<td>• dust • meteors crashing</td>
</tr>
<tr>
<td>thermosphere</td>
<td>80–500 km</td>
<td>1500°C–3000°C</td>
<td>• solar radiation</td>
</tr>
<tr>
<td>exosphere</td>
<td>Over 500 km</td>
<td>Not defined</td>
<td>• merges with outer space</td>
</tr>
</tbody>
</table>

Comprehension
What is weather?
Page 189
1. Weather is the condition of the atmosphere in a specific place and at a specific time.
2. Convection moves air and thermal energy throughout the troposphere.
3. An aneroid barometer contains a small capsule made of flexible metal. As atmospheric pressure changes, the capsule expands or contracts.
4. The SI unit for atmospheric pressure is the kilopascal (kPA). The kPA represents the vertical forces per unit area.
5. As the altitude increases, the density of the air decreases. Your ears try to balance the higher atmospheric pressure within your middle ear with lower external pressure.
6. (a) molecules spread out, resulting in lower atmospheric pressure
   (b) atmospheric pressure drops
   (c) atmospheric pressure increases
7. Wind is the movement of air from an area of higher pressure to lower pressure while an air mass is a parcel of air with similar temperature and humidity throughout.

8. When a high pressure system forms, the air mass cools, particles in the air lose kinetic energy, and the air becomes more dense. Wind is created. Clear skies often occur.

9. When a low pressure system forms, the air mass warms, it expands and rises, making the layer of air thicker. As the air rises, it cools. The water vapour may condense, producing clouds or precipitation.

Interpreting Illustrations

Weather patterns

Page 190

1. (a) cool temperatures, forming rain or snow, depending on elevation
   (b) strong, dry, warm winds called Chinooks form

2. Arrows should deflect to the right in the northern hemisphere and to the left in the southern hemisphere.

3. (a) polar easterlies
    (b) prevailing westerlies
    (c) northeast trade winds
    (d) southeast trade winds
    (e) prevailing westerlies
    (f) polar easterlies

4. (a) Warm air replaces cold air, therefore precipitation will result.
    (b) Cold air replaces warm air, therefore cooler, drier weather will occur.

5. Warm ocean water and winds lift moist air high into the atmosphere. The water vapour condenses, producing clouds and rain. The rising air produces a low pressure area at the ocean’s surface. Warm air rushes down towards the low pressure area. The Coriolis effect forces the air to rotate, causing a massive, spinning storm.

Assessment

Energy transfer in the atmosphere

Page 192


Chapter 11 Climate change occurs through natural processes and human activities.

Section 11.1 Natural Causes of Climate Change

Cloze Activity

Natural causes of climate change

Page 196

1. climate
2. paleoclimatologists
3. natural greenhouse effect
4. tilt; wobble; shape
5. water vapour
6. convection currents
7. Coriolis effect
8. El Niño-Southern Oscillation
9. carbon sink
10. weathering
11. catastrophic events

Comprehension

Factors that affect climate

Page 197

1. A decrease in the amount of greenhouse gases would lower the temperature on Earth.
2. An increase in the tilt of Earth would result in extreme seasonal changes. In the northern hemisphere, winters would be colder and summers would be warmer.
3. A change in Earth’s wobble will affect the angle of incidence of the Sun’s rays.
4. When Earth’s orbit is elliptical, Earth’s orbit takes it farther from the Sun, and less solar radiation reaches Earth’s surface.
5. As yearly temperatures increase, the atmosphere holds more water vapour and traps more thermal energy. The resulting increase in temperature causes more water to evaporate.
6. Melting glaciers add large amounts of salt-free water to the oceans. This raises the water levels and changes the environment of the ocean, threatening the survival of many species living in the ocean.

7. As the levels of carbon dioxide increase, the temperature on Earth increases.

8. A volcanic eruption results in molten rock and ash blocking out sunlight, and a release of water vapour and sulphur dioxide, which forms sulphuric acid. The sulphuric acid can reflect solar radiation and result in the lower levels of the atmosphere cooling.

Interpreting Illustrations
El Niño and La Niña
Page 198

1. (a) El Niño
   (b) Winds blowing west weaken and may even reverse.
   (c) La Niña
   (d) Stronger-than-normal winds push warm Pacific waters farther west, toward Asia. Cold, deep-sea waters then well up strongly in the Eastern Pacific, bringing cooler temperatures to northwestern North America.

2. (a) La Niña
   (b) Warm ocean water, clouds, and moisture are pushed away from North America.
   (c) El Niño
   (d) Sun-warmed surface water spans the Pacific Ocean.

Assessment
Natural causes of climate change
Page 199

Section 11.2 Human Activity and Climate Change
Comprehension
Climate Change
Page 203
1. • amount of Arctic sea ice is shrinking by 2 percent to 3 percent every decade
   • average sea level is rising by about 3 mm per year
   • average global temperature has risen by about 0.55°C since 1970

2. The greenhouse gases produced by human activity are carbon dioxide, methane, nitrous oxide (dinitrogen oxide), ozone, and chlorofluorocarbons.

3. Nitrous oxide is formed from the biological process of bacteria in ocean water, soil, and manure. Humans produce large amounts of nitrous oxide from the use of nitrogen-rich chemical fertilizers in farming and the improper disposal of human and animal waste.

4. The main cause of the depletion of Earth’s protective ozone layer are chlorofluorocarbons (CFCs).

5. Albedo is the amount of radiation reflected by a surface.

6. GMCs take into account changes in greenhouse gas concentrations, albedo, ocean currents, winds, and surface temperatures.

7. Northern Canada has rising temperatures especially in the arctic regions. Areas of permafrost are melting, and the ice cover in the Arctic Ocean is rapidly shrinking.

8. The plans by the Canadian government include reducing greenhouse gas emission from trucks and cars, introducing policies requiring greenhouse gas-producing industries to reduce emissions, increasing the types of energy-efficient products available, and setting guidelines for improving indoor air quality.

Applying Knowledge
Greenhouse gases
Page 204
1. See figure 11.16 on page 484 in BC Science 10 textbook.
   Water vapour: 65 percent
   Carbon dioxide: 25 percent
Other gases, such as methane, nitrous oxide, CFCs, and ozone: 10 percent

2.

<table>
<thead>
<tr>
<th>Greenhouse gas</th>
<th>Chemical formula</th>
<th>Source from human activity</th>
<th>Global Warming Potential (GWP)</th>
</tr>
</thead>
</table>
| carbon dioxide        | CO₂              | • combustion of fossil fuels  
                          |                                 | • deforestation                | 1                             |
| methane               | NH₃              | • combustion of fossil fuels  
                          |                                 | • livestock  
                          |                                 | • waste dumps  
                          |                                 | • rice paddies               | 25                            |
| nitrous oxide         | N₂O              | • chemical fertilizers  
                          |                                 | • burning waste  
                          |                                 | • industrial processes        | 298                           |
| chlorofluoro carbons  | various          | • liquid coolants  
                          |                                 | • refrigeration  
                          |                                 | • air conditioning            | 4750–5310                     |

3. Water vapour is not included in the table because human activities have very little direct effect on the amount of water vapour in the atmosphere. Ozone is not included in the table because it is continually broken down and reformed in the atmosphere, and so it is very difficult to determine its GWP.

Extension Activity
Strategies for addressing climate change
Page 205
1. Answers will vary. Table 11.4 on page 496 gives some general strategies for reducing greenhouse gas emissions.
2. Answers will vary depending on the individual and his or her local environment.

Assessment
Human activity and climate change
Page 206

Chapter 12 Thermal energy transfer drives plate tectonics.
Section 12.1 Evidence for Continental Drift
Cloze activity
Evidence for continental drift
Page 210
1. supercontinent
2. Pangaea
3. geological structures; fossils; ancient glaciers
4. mountain ranges
5. tectonic plates
6. Mid-Atlantic Ridge
7. magnetic stripping
8. magma
9. spreading ridge
10. hot spot
11. plate tectonic theory

Applying Knowledge
Theories related to continental drift
Page 211

<table>
<thead>
<tr>
<th>Continental drift</th>
<th>Paleomagnetism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed by: Alfred Wegener</td>
<td>Main points:</td>
</tr>
<tr>
<td>Main points:</td>
<td>• continents were in motion</td>
</tr>
<tr>
<td>• Pangaea (supercontinent) existed</td>
<td>• Pangaea (supercontinent) existed</td>
</tr>
<tr>
<td>• continental shelves matched up</td>
<td>• continental shelves matched up</td>
</tr>
<tr>
<td>• compared geological structures, fossils,</td>
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</tr>
<tr>
<td>and evidence of ancient glaciers</td>
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</tr>
<tr>
<td>Sea floor spreading</td>
<td>Main points:</td>
</tr>
<tr>
<td>Proposed by: Harry Hess</td>
<td>• observed data on the age of ocean</td>
</tr>
<tr>
<td>Main points:</td>
<td>rocks, sediment thickness, and</td>
</tr>
<tr>
<td>• observed data on the age of ocean</td>
<td>magnetic stripping</td>
</tr>
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<td>rocks, sediment thickness, and magnetic</td>
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</tr>
<tr>
<td>stripping</td>
<td>rocks, sediment thickness, and</td>
</tr>
<tr>
<td>• convection currents under Earth’s surface</td>
<td>magnetic stripping</td>
</tr>
<tr>
<td>bring up magma which caused the sea</td>
<td>• convection currents under Earth’s</td>
</tr>
<tr>
<td>floor to spread apart</td>
<td>surface bring up magma which caused</td>
</tr>
<tr>
<td></td>
<td>the sea floor to spread apart</td>
</tr>
</tbody>
</table>

Plate tectonic theory
Proposed by: J. Tuzo Wilson
Main points:
• suggested chains of volcanic islands were formed when a tectonic plate passed over a stationary hot spot
• continents break up at certain areas, move across Earth’s surface, then rejoin

Interpreting Illustrations
Visual observations supporting continental drift
Page 212
1. Wegener used analysis of rocks and ridges, fossils, and evidence of ancient glaciers.
2. (a) These magnetic patterns were measured by a magnetometer.
   (b) These patterns show that Earth’s magnetic field switches over time.
3. The Hawaiian Islands were formed when a tectonic plate passed over a stationary hot spot.

Assessment
Evidence for continental drift
Page 213
Section 12.2 Features of Plate Tectonics

Interpreting Illustrations

Layers of the Earth

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1. (a) inner core
   (b) outer core
   (c) lower mantle
   (d) upper mantle
   (e) crust

2.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
<th>State</th>
<th>General composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) inner core</td>
<td>1216 km</td>
<td>solid</td>
<td>iron, nickel</td>
</tr>
<tr>
<td>(b) outer core</td>
<td>2270 km</td>
<td>liquid</td>
<td>iron, nickel</td>
</tr>
<tr>
<td>(c) lower mantle</td>
<td>2225 km</td>
<td>solid</td>
<td>magnesium, iron</td>
</tr>
<tr>
<td>(d) upper mantle</td>
<td>660 km</td>
<td>solid, molten</td>
<td>iron, magnesium</td>
</tr>
<tr>
<td>(e) crust</td>
<td>5–60 km</td>
<td>solid, brittle</td>
<td>granite, basalt</td>
</tr>
</tbody>
</table>

3. The lithosphere is the layer made up of the crust and the uppermost mantle while the asthenosphere is a partly molten layer in Earth's upper mantle just below the lithosphere.

Comprehension

Features of plate tectonics

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1. Geologists believe that the asthenosphere is heated by radioactive decay from large quantities of radioactive elements such as uranium.
2. Scientists hypothesize the mantle convection is one of the driving forces behind plate movement.
3. A rift valley occurs on land, while a spreading ridge occurs in the ocean.
4. The heavy oceanic plate will dive deep under the lighter continental plate in an event known as subduction.
5. Earthquakes and volcanic eruptions occur at subduction zones.

6. (a) divergent
   (b) convergent
   (c) transform

7.

<table>
<thead>
<tr>
<th>Geographic location</th>
<th>Plate interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. East African Rift</td>
<td>divergence</td>
</tr>
<tr>
<td>2. Juan de Fuca plate</td>
<td>oceanic-continental convergence</td>
</tr>
<tr>
<td>3. Islands of Japan</td>
<td>oceanic-oceanic convergence</td>
</tr>
<tr>
<td>4. Himalayan mountains</td>
<td>continental-continental convergence</td>
</tr>
<tr>
<td>5. San Andreas Fault</td>
<td>transform fault</td>
</tr>
</tbody>
</table>

8. Subduction does not occur when continental plates collide. The plates have similar densities so this prevents either one from being forced down into the mantle.

Applying Knowledge

Seismic waves, earthquakes, and volcanoes

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1.

<table>
<thead>
<tr>
<th>Seismic wave</th>
<th>Abbreviation</th>
<th>General diagram of wave</th>
<th>Description of action</th>
<th>Type of material it travels through</th>
<th>Speed it travels at</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary wave</td>
<td>P</td>
<td></td>
<td>ground squeezes and stretches</td>
<td>solids, liquids, gases</td>
<td>fast</td>
</tr>
<tr>
<td>secondary wave</td>
<td>S</td>
<td></td>
<td>ground motion is perpendicular to direction of wave travel</td>
<td>solids, but not liquids</td>
<td>slower</td>
</tr>
<tr>
<td>surface wave</td>
<td>L</td>
<td></td>
<td>rolling action</td>
<td>solids</td>
<td>slowest</td>
</tr>
</tbody>
</table>

2. A seismometer is a device that measures the amount of ground motion caused by an earthquake.
3. Magnitude is a number that rates the strength (energy) of an earthquake. Higher magnitude numbers indicate larger, more devastating earthquakes.
4. The Richter scale is often used to measure the magnitude of an earthquake.
5. The focus is the location inside Earth where an earthquake starts, and the epicentre is the point on Earth's surface directly above the focus.
6. Shallow focus occurs 1–70 km below the surface, intermediate focus occurs 70–300 km below the surface, while deep focus occurs at depths greater than 300 km.

7.

<table>
<thead>
<tr>
<th>Geographic location</th>
<th>Type of volcano</th>
<th>Description of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Garibaldi volcano</td>
<td>composite</td>
<td>repeated eruptions at subduction zone</td>
</tr>
<tr>
<td>Anahim Volcanic Belt</td>
<td>shield</td>
<td>located over hot spot</td>
</tr>
<tr>
<td>Krafla volcano</td>
<td>rift eruptions</td>
<td>rift eruptions along cracks in lithosphere</td>
</tr>
</tbody>
</table>

Assessment

Features of plate tectonics

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