

Unit 1 Review, pages 138–145

Knowledge

1. (b)
2. (c)
3. (b)
4. (b)
5. (a)
6. (d)
7. (a)
8. (d)
9. (a)
10. (b)
11. (c)
12. (b)
13. True
14. False. *Lewis* diagrams show only the valence electrons in an atom.
15. False. When an atom *loses* an electron, it becomes a cation. OR When an atom gains an electron, it becomes *an anion*.
16. False. Isotopes are atoms of the same element that have different numbers of *neutrons*.
17. False. *Mendeleev's* proposed periodic table left spaces for yet undiscovered elements.
18. True
19. True
20. False. A *non-polar* covalent bond forms when the electronegativity difference between the atoms is 0.
21. True
22. True
23. True
24. False. *Plastics* are frequently recycled into other useful products.
25. (a) (iii)
(b) (ii)
(c) (i)
(d) (iv)
26. Chemistry is the study of the composition of matter and its interactions.
27. The results of Rutherford's experiment suggested that an atom contains a dense, positively charged core because a few of the positively charged alpha particles that bombarded the foil were deflected by passing close to another positive charge. This positive charge was concentrated in the nucleus.
28. (a) Br^- forms from the Br atom.
(b) N^{3-} forms from the N atom.
(c) K^+ forms from the K atom.
(d) Mg^{2+} forms from the Mg atom.
(e) S^{2-} forms from the S atom.

- 29. (a)** SO_4^{2-} is the sulfate ion.
(b) NO_3^- is the nitrate ion.
(c) CO_3^{2-} carbonate ion.
(d) BrO_3^- is the bromate ion.
(e) ClO_4^- is the perchlorate ion.
(f) CN^- is the cyanide ion.
(g) SO_3^{2-} is the sulfite ion.
- 30. (a)** The chemical formula for chlorate is ClO_3^- .
(b) The chemical formula for ammonium is NH_4^+ .
(c) The chemical formula for hydrogen carbonate is HCO_3^- .
(d) The chemical formula for hypochlorite is ClO^- .
(e) The chemical formula for dichromate is $\text{Cr}_2\text{O}_7^{2-}$.
(f) The chemical formula for permanganate is MnO_4^- .
(g) The chemical formula for hydrogen sulfate is HSO_4^- .
- 31.** Answers may vary. Sample answer: Radioisotopes undergo radioactive decay by emitting nuclear radiation.
- 32. (a)** The periodic law states that when the elements are arranged in order of increasing atomic number, their properties show a periodic recurrence and gradual change.
(b) A periodic trend is a pattern in properties of elements that we observe as we move across a period on the periodic table.
- 33.** The contribution to the periodic table made by Dobereiner was his early attempt to classify small groups of elements according to their properties.
- 34.** If an atom has high ionization energy, its electron affinity is also high.
- 35. (a)** An electrolyte is a compound that conducts an electric current when it is dissolved in water.
(b) Ionic compounds are electrolytes because they separate into ions when they are in solution. These charged entities are free to move from one place to another and thus can conduct electricity.
- 36.** The state in which both ionic and molecular compounds exist under ambient temperatures is the solid state.
- 37. (a)** A covalent bond is a force of attraction between two atoms that results when two atoms share one or more pairs of valence electrons.
(b) A covalent bond differs from an ionic bond in that electrons are shared by atoms in a covalent bond and transferred between atoms to form an ionic bond.
- 38.** The difference between electronegativity and electron affinity is that electronegativity is the ability of an atom to attract bonding electrons to itself, and electron affinity is the energy change that occurs when an atom gains an electron.
- 39. (a)** NaBr is sodium bromide.
(b) MgS is magnesium sulfide.
(c) CuOH is copper(I) hydroxide.
(d) SnCl_2 is tin(II) chloride.
(e) K_2SO_3 is potassium sulfite.

- 40. (a)** SO_3 is sulfur trioxide.
(b) AsCl_3 is arsenic trichloride.
(c) NO is nitrogen monoxide.
(d) CCl_4 is carbon tetrachloride.
(e) P_2O_5 is diphosphorus pentoxide.
- 41. (a)** The chemical formula for sodium fluoride is NaF .
(b) The chemical formula for calcium chloride is CaCl_2 .
(c) The chemical formula for mercury(I) oxide is Hg_2O .
(d) The chemical formula for potassium cyanide is KCN .
(e) The chemical formula for ammonium sulfate is $(\text{NH}_4)_2\text{SO}_4$.
(f) The chemical formula for magnesium nitrate is $\text{Mg}(\text{NO}_3)_2$.
(g) The chemical formula for barium phosphate is $\text{Ba}_3(\text{PO}_4)_2$.
(h) The chemical formula for magnesium sulfite is MgSO_3 .
(i) The chemical formula for nickel(II) perchlorate is $\text{Ni}(\text{ClO}_4)_2$.
(j) The chemical formula for copper(I) sulfide is Cu_2S .
- 42. (a)** The chemical formula for sulfur dioxide is SO_2 .
(b) The chemical formula for carbon tetraiodide is CI_4 .
(c) The chemical formula for silicon dioxide is SiO_2 .
(d) The chemical formula for phosphorous trichloride is PCl_3 .
(e) The chemical formula for dinitrogen tetraoxide is N_2O_4 .
- 43.** The two sources of most molecular compounds are living things (renewable resources) and fossil fuels (non-renewable resources).
- 44.** Reusing an object means repurposing the object for another use without reprocessing it. Recycling involves reprocessing a material before it is used in another product.
- 45.** There is a need for scientists to develop products such as insect repellents to protect humans from organisms or substances that are potentially harmful to human health.
- 46.** In a hydrogen bromide molecule, the electron density would be greater around the bromine atom than around the hydrogen atom.
- 47.** A molecule that contains polar bonds can be a non-polar molecule if the polar bonds are arranged symmetrically about the central atom so that the partial charges balance.
- 48. (a)** The three different types of intermolecular forces are dipole–dipole forces, London dispersion forces, and hydrogen bonds.
(b) Dipole–dipole forces and London dispersion forces are also referred to as van der Waals forces.
- 49.** Water is a liquid at normal temperatures because of the strong polarity of the molecules and the strong hydrogen bonds between its molecules. Methane and ammonia are gases at normal temperatures because their molecules are attracted by much weaker intermolecular forces than those of water molecules.
- 50.** The property of water that causes water to form beads and droplets is high surface tension.
- 51.** To say that one aim of green chemistry is to increase energy efficiency means that processes are carried out at lower temperatures or wastes are turned into usable energy, so that less energy is used to do the same amount of work.
- 52. (a)** Thoughts are not matter because they do not have mass or volume.
(b) Air is matter because it has both mass and volume.
- 53.** Neutrons were discovered later than electrons and protons because neutrons have no charge. Protons and electrons are deflected by an electric charge, which makes them easier to detect.

54. Table 1 Atomic Data for Three Elements

| | Cobalt | Iron | Silver |
|--------------------|---------------|-------------|---------------|
| atomic number | 27 | 26 | 47 |
| mass number | 59 | 56 | 108 |
| number of protons | 27 | 26 | 47 |
| number of neutrons | 32 | 30 | 61 |

55. (a) An octet is a complete outer valence level in an atom. It usually contains 8 electrons.

(b) The octet rule states that when atoms combine with each other, they tend to attain an octet.

(c) The octet rule relates to the formation of ions because atoms will lose or gain enough electrons to attain a stable octet.

56. (a) The IUPAC name for HgCl is mercury(I) chloride.

(b) The IUPAC name for HgO is mercury(II) oxide.

(c) The IUPAC name for HgNO₃ is mercury(I) nitrate.

57. (a) The three most common types of nuclear radiation are alpha particles, beta particles, and gamma rays.

(b) Alpha particles are helium nuclei, consisting of 2 protons and 2 neutrons. Beta particles are electrons. Gamma rays are high-energy electromagnetic radiation.

58. Given: percent abundance of U-238 = 99.28 %

percent abundance of U-235 = 0.71 %

percent abundance of U-234 = 0.0054 %

Required: atomic mass of uranium

Analysis: atomic mass = % abundance of isotope 1 (mass of isotope 1) +
% abundance of isotope 2 (mass of isotope 2) +
% abundance of isotope 3 (mass of isotope 3)

Solution:

atomic mass of uranium = 99.28 % (238 u) + 0.71 % (235 u) + 0.0054 % (234 u)
= 236.2864 + 1.6685 + 0.012 636 [extra digits carried]
= 237.97 u [3 extra digits carried]

atomic mass of uranium = 2.4×10^2 u

Statement: The atomic mass of uranium is 2.4×10^2 u.

59. (a) I might use the Bohr–Rutherford diagrams to the right and the left of the empty square to draw the Bohr–Rutherford diagram for boron by averaging the numbers of protons, neutrons, and electrons in those atoms.

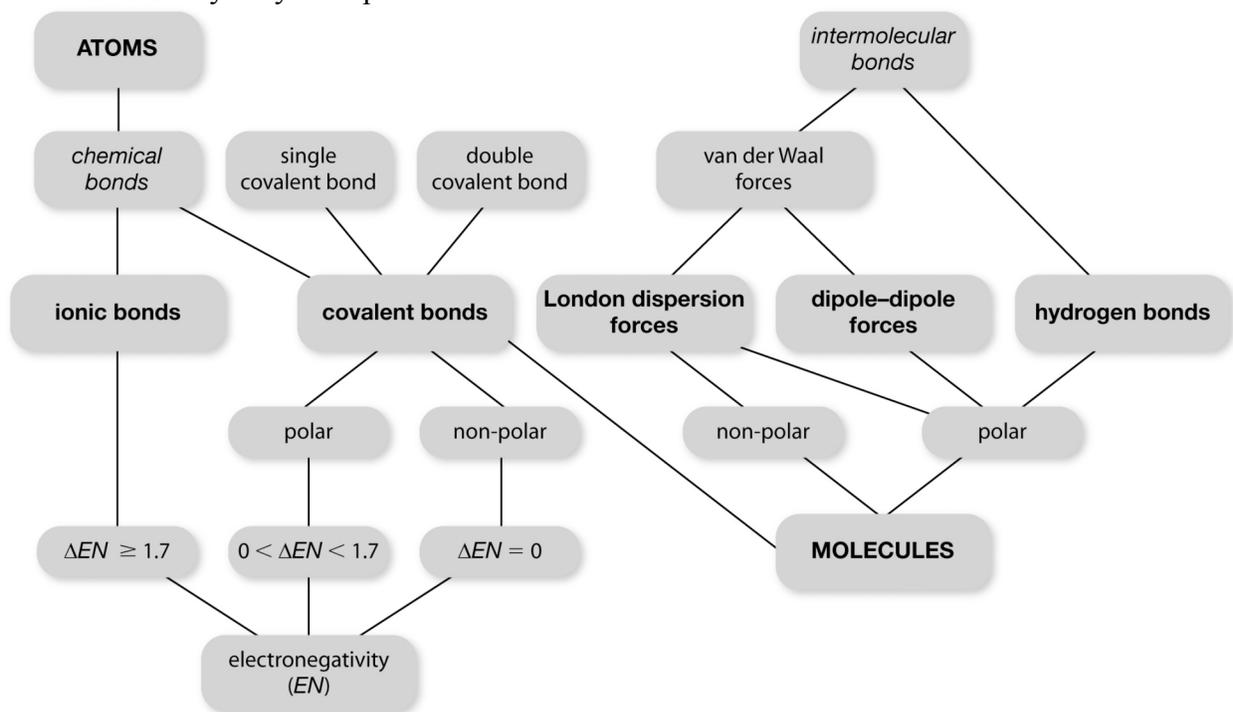
(b) I could use the Bohr–Rutherford diagram for aluminum, Al, to check that my Bohr–Rutherford diagram for boron is correct because aluminum is in the same group as boron. Both elements have the same number of valence electrons, but aluminum has one more valence shell.

60. The modern periodic table and the periodic table proposed by Dmitri Mendeleev differ in that the current table is ordered by atomic number instead of atomic mass and it contains many elements not known at the time Mendeleev made his table.

61. Dobereiner’s triads are more similar to a group on the periodic table than to a period because they include elements with similar properties.

- 62. (a)** A chemical bond is a force of attraction holding two atoms or ions together.
(b) An ionic bond is an electrical attraction holding ions together in a compound.
(c) An ionic bond is a type of chemical bond because positive and negative charges cause a force of attraction and ions are held together.
- 63. (a)** Ionic compounds have high melting points because their ions are held tightly together in a repeating pattern by strong electrostatic forces.
(b) Ionic compounds are hard because their strong bonds resist being stretched.
(c) An ionic compound breaks when struck with a hammer because its lattice structure is offset, and like charges repel each other.
(d) Ionic compounds conduct electricity when dissolved because the ions break apart in solution. These particles are free to move and carry a charge.
- 64.** The examples of each type of bond may vary from those given below.
(a) A single covalent bond, such as the C–H bond in a methane molecule, involves the sharing of one pair of electrons by the two bonded atoms.
(b) A double covalent bond, such as the C=O bond in a carbon dioxide molecule, involves the sharing of two pairs of electrons by the two bonded atoms.
(c) A triple covalent bond, such as the N≡N bond in a nitrogen gas molecule, involves the sharing of three pairs of electrons by the two bonded atoms.
- 65. (a)** H and C form a polar covalent bond.
(b) N and O form a polar covalent bond.
(c) K and Br form an ionic bond.
(d) O and O form a non-polar covalent bond.
(e) H and O form a polar covalent bond.
- 66.** Non-polar covalent bonds involve equal sharing of electron pairs between two atoms. Polar covalent bonds involve unequal sharing of electrons between two atoms.
- 67.** Molecular compounds need a naming convention different from that used for ionic compounds because non-metals can combine in many more ways than a metal and a non-metal, resulting in many compounds that contain the same two (or more) non-metal elements.
- 68. (a)** The energy content of an artificial sweetener is much lower than that of the same mass of sugar.
(b) The sweetness of an artificial sweetener per unit of mass is much higher than that of sugar.
- 69.** Compostable or biodegradable products are generally considered to be more environmentally friendly than non-biodegradable products because they decompose to produce harmless substances.
- 70. (a)** Insect repellents are often applied directly to the skin because they are designed to either mask the scent of a human or to have a scent that is repulsive to insects. Biting insects require blood, which can only be obtained by puncturing the skin. If they stay away from your skin, you will not be bitten.
(b) Insecticides usually are applied to the environment instead of directly on a person because they are toxic. They are designed to kill insects and might also be harmful to humans.
- 71.** The two factors that determine whether or not a molecule is polar are whether it contains polar bonds or not and, if it does, whether they are arranged symmetrically about the central atom(s). If the molecule contains polar bonds and they are arranged asymmetrically, then the molecule will be polar. Otherwise it will be non-polar.

- 72. (a)** Dipole–dipole forces are attractions between the slightly positive end of one polar molecule and the slightly negative end of an adjacent polar molecule.
- (b)** The types of molecules that contain the strongest dipole–dipole forces are molecules in which a positive hydrogen atom is covalently bonded to a highly electronegative atom of nitrogen, oxygen, or fluorine. The particularly strong dipole–dipole force that occurs is called a hydrogen bond.
- 73. (a)** The type of intermolecular force that exists between all molecules, whether they are polar or not, is London dispersion forces.
- (b)** These forces are more noticeable between non-polar molecules than polar molecules because polar molecules also experience stronger dipole–dipole forces, which mask the effect of the weaker London dispersion forces.
- 74.** Answers may vary. Sample answer:



- 75.** Two ways in which toxicity must be considered in developing and using green materials are by making sure the material itself is not toxic and that its waste is not toxic.
- 76.** The electron energy levels proposed by Niels Bohr are similar to the rungs on a ladder because electrons move from level to level without occupying any of the space between levels. Similarly, if you are on a ladder, you are on a specific rung and not between rungs.
- 77. (a)** The atomic number of selenium is 34. The atomic number is the number of protons found in the nucleus of an atom, and most selenium atoms contain 34 protons.
- (b)** The mass number of a selenium atom is calculated by adding the number of protons and the number of neutrons. Since most selenium atoms contain 34 protons and 45 neutrons, the mass number of a selenium atom is $34 + 45 = 79$.
- 78. (a)** All isotopes used in medical diagnosis and treatment are radioisotopes.
- (b)** Answers may vary. Sample answer: Three examples of useful radioisotopes are iodine-131, which is used to diagnose and treat thyroid disorders; americium-241, which is used in smoke detectors; and cobalt-60, which is used in food irradiation.

79. (a) Hydrogen is included in the same column of the periodic table as the alkali metals because it contains one valence electron, as alkali metals do.

(b) Hydrogen is not considered to be an alkali metal because it does not have the same physical properties as the alkali metals.

80. (a) The periodic trends of atomic radius, ionization energy, electron affinity, and electronegativity vary as follows: Atomic radius decreases as you move from left to right across a period and as you move up a group, but ionization energy, electron affinity, and electronegativity all increase as you move from left to right and up a group.

(b) The periodic trend of atomic radius differs from the trend followed by ionization energy, electron affinity, and electronegativity because protons are added but no additional electron shells are added as you move from left to right across a period. This increases the number of positive charges in the nucleus, and thus the attractive force on each electron becomes stronger. As a result, electrons are pulled closer to the nucleus, decreasing atomic radius. Having electrons closer to the nucleus increases the amount of energy needed to remove an electron, the attraction of the atom for additional electrons, and the attraction for bonded electrons. Therefore, ionization energy, electron affinity, and electronegativity increase as atomic radius decreases.

81. (a) Copper loses electrons to become an ion. Thus, it loses an energy level and the ion is smaller than the atom.

(b) Sulfur gains electrons to become an ion. The additional electrons increase the repulsion among the electrons so they spread apart, which makes the ion larger than the atom.

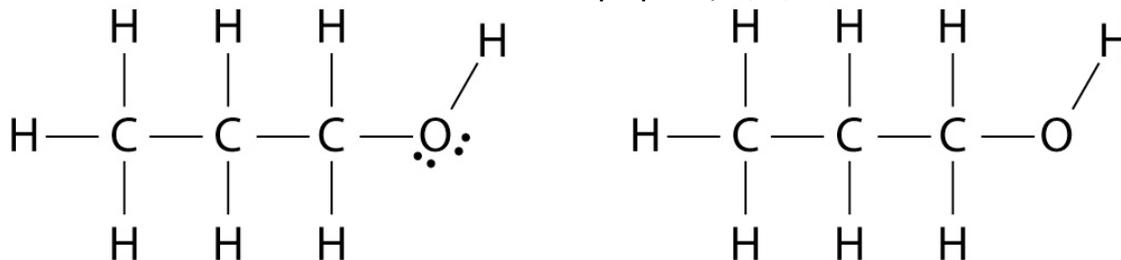
82. (a) To determine how easily a bromine atom forms an ion, you would be more concerned with its electron affinity than its ionization energy. Bromine forms ions by gaining an electron, and its electron affinity will tell you how easily bromine attracts electrons.

(b) To determine how easily a magnesium atom forms an ion, you would be more concerned with its ionization energy than its electron affinity. Magnesium forms ions by losing electrons, and its ionization energy will tell you the amount of energy required to remove electrons.

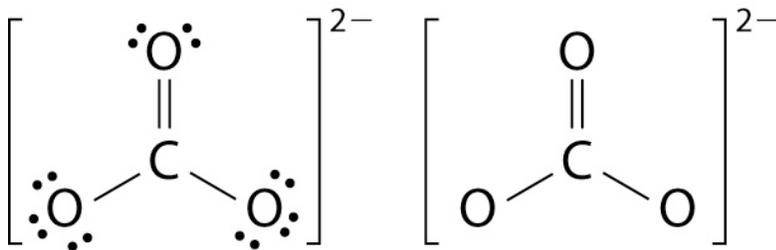
83. (a) The structure of solid potassium chloride is a crystal lattice consisting of huge numbers of potassium ions and chloride ions, in a 1:1 ratio, arranged in a crystal.

(b) Four properties of potassium chloride that are common to other ionic compounds include relatively high melting point, high boiling point, being an electrolyte, and shattering when hit.

84. Lewis structure and structural formula for propanol, C_3H_7OH :



85. Lewis structure and structural formula for carbonate ion, CO_3^{2-} :



- 86.** An ionic compound might contain both ionic and covalent bonds if at least one of the ions is a polyatomic ion. The atoms in a polyatomic ion are covalently bonded. In NaNO_3 , Na^+ and NO_3^- are connected by an ionic bond and the atoms within NO_3^- are covalently bonded.
- 87. (a)** The formula for anhydrous cobalt(II) chloride is CoCl_2 and the formula for the hydrate, cobalt(II) chloride hexahydrate, is $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$.
- (b)** The formula for anhydrous magnesium sulfate is MgSO_4 and the formula for the hydrate, magnesium sulfate heptahydrate, is $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$.
- 88.** When checking a food label to see if the food contains sugar, you would look for a chemical with the *-ose* suffix, which indicates a sugar.
- 89.** Answers may vary. Sample answers: I agree with the statement that reusable products are generally more environmentally friendly than comparable products because it is better to use a single item many times than to use many different items only once each. Energy is only needed to produce and transport one item, and there is only one item to dispose of. A reusable product will always be more environmentally friendly than a disposable product made of the same raw materials (e.g., fossil fuels). However, a reusable item made of a non-renewable resource that is not recyclable or biodegradable (e.g., plastic) is much less environmentally friendly than a disposable item that is made from a renewable resource and is biodegradable.
- 90.** Renewable resources, such as wood and water, can be replaced relatively quickly. Non-renewable resources, such as coal and petroleum, cannot be replaced as quickly as they are used.
- 91. (a)** Methane is a non-polar molecule.
- (b)** Methane is non-polar because although methane contains polar bonds, they are arranged symmetrically so the molecule has no positively charged end and no negatively charged end.
- 92. (a)** Answers may vary. Sample answer: Reduce means to consume fewer resources by doing things such as walking or riding a bike to work instead of driving in a car; driving fuel-efficient cars even though they are not very fast or impressive looking; keeping thermostats set to lower temperatures in winter and wearing warmer clothes around the house; and choosing not to buy new products unnecessarily. Reuse means to extend the life of products as long as possible before replacing them, or to use them for another purpose. For example, drinking the water purchased in a disposable plastic bottle and then immediately discarding the bottle is wasteful and not good for the environment. It is better to use a bottle that can be cleaned and refilled many times before it finally has to be discarded. Reusable cloth shopping bags can carry goods home from the store many times and take the place of disposable plastic bags. Recycle means to make a conscious effort to make sure that the garbage and trash you discard does not simply get taken straight to a landfill. Instead, either you or the garbage collector should separate out items that can be processed to yield raw materials for the making of new products. You must make sure that these items will be sent to the facilities that can properly process them so they can be used to make other products.

(b) Answers may vary. Sample answer: Reduce is the most important strategy for protecting the environment. Excessive consumption requires excessive production, and that leads to more pollution and more garbage and trash going to landfills. It also leads to the use of more energy to fuel the production. Consuming less is a simple fix to these problems; it just takes a willingness to accept a less consumption-oriented lifestyle. Reuse is the next most important strategy. Reusing products delays the need for their replacement, which in turn reduces consumption and the production required to support the consumption. Recycle is an important green strategy, but it has hidden environmental costs, such as the energy required for processing the recycled items and the energy used in manufacturing new goods containing recycled materials. Energy is also required to transport the recycled items to a processing facility and the goods made from recycled materials to the marketplace. Also, pollutants may be released during the processing of recycled materials. For these reasons, recycle is the least important of the three Rs.

93. Since methane is a gas, ethanol is a liquid, and paraffin is a soft solid at ambient temperatures, the intermolecular forces at ambient temperatures are most likely strongest in paraffin and weakest in methane. The forces between ethanol molecules are stronger than those in methane and weaker than those in paraffin.

94. The main property of water that helps to prevent lakes freezing all the way down to the bottom is the low density of ice compared to that of liquid water at the same temperature. When the water molecules are frozen into ice on the surface of the water they cannot move around and carry thermal energy from the lower parts of the lake to the very cold air above. In this way, the ice separates the liquid water from the air, and allows the liquid water to stay relatively warm even when the air is very cold.

95. A beach heats up faster than the adjacent water during the day because the high heat capacity of water prevents the water from heating up as much. Similarly, at night the higher heat capacity of water helps the water to stay relatively warm while the beach cools quickly.

96. Upcycling uses energy more efficiently than recycling by repurposing objects and materials without their having to be processed. Reprocessing uses energy. Recycling requires energy for processing materials.

97. (a) Theoretical knowledge is based on ideas and is used to explain observations. Empirical knowledge comes from observations and is used to support ideas.

(b) Answers may vary. Sample answer: An example of theoretical knowledge is our understanding of the structure of an atom.

(c) Answers may vary. Sample answer: An example of how empirical knowledge can solve a problem is using observed properties of substances to determine what safety measures are necessary for the storage of substances that react with other substances.

98. (a) Metals are on the left and middle of the periodic table. These elements all have similar properties, such as being solid (usually) and having the ability to conduct electricity.

(b) Non-metals are on the right side of the periodic table. These elements have certain similar properties, such as a tendency to form anions in compounds (except for the noble gases).

(c) Metalloids are between metals and non-metals on the periodic table. Elements that have some properties of metals and some properties of non-metals are classified as metalloids.

(d) Groups are vertical columns on the periodic table. Elements in a group have similar properties.

(e) Periods are horizontal rows on the periodic table. Elements in one period show the same periodic trends as elements in other periods.

- 99. (a)** A Bohr–Rutherford diagram and a Lewis symbol for a fluorine atom both show the nucleus and the valence electrons.
- (b)** It might be most helpful to use a Bohr–Rutherford diagram if you need to know the composition of the nucleus, the total number of electrons, or the number of valence shells.
- (c)** You might choose to use a Lewis symbol instead of a Bohr–Rutherford diagram when explaining ion formation or chemical reactions, and the valence electrons are all that is important.
- 100. (a)** Effective nuclear charge is the net attractive force of the positive nucleus on an electron in an atom. The force depends on both the number of protons and the number of electrons.
- (b)** Effective nuclear charge affects atomic radius by pulling electrons closer to the nucleus as the number of protons increases but no new electron shells are added. Thus, atomic radius decreases as you move from left to right across a period.
- (c)** Effective nuclear charge affects electron affinity because the greater the effective nuclear charge, the greater the energy change when electrons are gained.
- 101.** Lewis symbols are helpful when representing the formation of an ionic bond because they can easily show how electrons are transferred to produce octets in each atom’s valence shell. They also help you to see how many anions and cations are required to balance the charges.
- 102. (a)** The electronegativities of magnesium and iodine are 1.3 and 2.7, respectively, giving an electronegativity difference of 1.4.
- (b)** The bond that forms between a magnesium atom and an iodine atom is polar covalent.
- 103.** Aluminum sulfide, Al_2S_3 , is called a binary compound because it contains only two different elements.
- 104. (a)** The type of intermolecular force that acts between all molecules is London dispersion force.
- (b)** The type of intermolecular force that acts only between polar molecules is dipole–dipole force.
- (c)** The type of intermolecular force that acts between polar molecules that contain hydrogen and a highly electronegative element is hydrogen bond.
- 105. (a)** The force that, in general, can be used to explain the unique properties of water is the hydrogen bond.
- (b)** Five unusual properties of water are high melting point, high boiling point, high surface tension, high specific heat capacity, and the low density of ice.
- 106. (a)** A product that can be applied to lawns with dry clay soils must affect the surface tension of water. Surface tension is what causes water to form beads. To keep the water from forming beads on dry soil, it will be necessary to reduce the water’s surface tension.
- (b)** Answers may vary. Sample answer: I would use powdered detergent as the main ingredient in this product. Soaps and detergents are known to reduce surface tension in water, so a detergent would be a good choice.

(c) I would have to determine the toxicity of the ingredients in the product to make sure that the product is safe both for people applying the product and for pets and wild animals visiting the lawn. In addition, the product cannot harm plants, particularly the grass in the lawns to which it is applied. It would be necessary to discover through research or experiment whether or not the product harms plants. The lifetime of the ingredients in the environment is also of concern. If the ingredients break down too soon, they will not perform their function as effectively. On the other hand, if they only break down very slowly, they will eventually move into the surrounding environment and perhaps cause problems. Accordingly, the chemical stability of the ingredients would have to be found through research or experiment. Finally, the product would have to be tested to make sure that it does not have any unanticipated effects on the surroundings, such as killing insects, reacting with other components in the environment, or changing the appearance of the lawn.

107. Answers may vary. Sample answer: I do not believe that it is reasonable to expect PLA to turn into fully digested compost within a month. Biodegradable plastics do not break down as readily as kitchen waste and lawn trimmings in compost piles. Special conditions are needed to accelerate the breakdown of biodegradable plastics. Typically, a biodegradable plastic must be kept for 50 days at 55 °C and 90 % humidity. Home composters do not maintain such conditions, so they are not likely to break down biodegradable plastics in a reasonable time and certainly not within a month. My relative can certainly compost kitchen scraps and lawn clippings. However, items made of biodegradable plastics should be separated from other garbage and composted at an industrial facility designed for that purpose.

108. Three advantages of converting to green materials and processes are increases in energy efficiency, reduced reliance on non-renewable resources, and reduced negative effects on the environment.

109. (a) “Chemistry is called the central science” means that chemistry connects the physical sciences (physics, Earth science) with the life sciences (biology).

(b) Answers may vary. Sample answer: Chemistry connects physics and biology when energy released by chemical reactions in the human body facilitate motion.

(c) Answers may vary. Sample answer: Chemistry connects biology and Earth science when organisms decompose, forming a component of soil.

110. (a) Answers may vary. Sample answer: Terms other than “polyatomic” that contain the prefix *poly-* include “polygon,” “polyester,” and “polyunsaturated.”

(b) The meaning of *poly-* in these terms relates to the meaning of this prefix in “polyatomic ion” because *poly-* means “many” in each instance.

111. (a) Answers may vary. Sample answer: I ate some salty food, so I ingested Na^+ , I^- , and Cl^- ions. I drank milk, so I ingested K^+ and Ca^{2+} ions.

(b) Answers may vary. Sample answer: I know I ate too much salt, so my fluid retention might be affected. The calcium I ate will make my bones stronger, and the iodine will improve my metabolism.

112. Four ways the homeowner could prevent radon gas from entering the house shown in Figure 8 in Research This in Section 1.4 are capping the sump, sealing cracks in the basement walls, caulking around windows, and having the water supply treated to remove radon.

113. (a) There are 14 valence electrons around Xe in the compound XeF_6 —8 from the Xe atom and 1 from each of the 6 F atoms.

(b) The compound XeF_6 does not follow the octet rule because Xe contains more than 8 electrons in its valence shell.

(c) Large noble gas atoms form compounds with active non-metals but small noble gas atoms, such as those of He or Ne, do not because the valence shell in large atoms is protected from the positively charged nucleus by other electrons in lower shells. Valence electrons in larger atoms are farther apart and are less affected by repulsive forces.

114. Answers may vary. Sample answer: Arm wrestling is another analogy that might be used to explain the effects of differences in electronegativity between bonded atoms. The stronger arm favours greater movement.

115. Answers may vary. Sample answer: Two compounds that are usually known by their common names, not their IUPAC names, are Epsom salts (magnesium sulfate) and baking soda (sodium hydrogen carbonate).

116. Answers may vary. Sample answer: A product made by upcycling is bags made from juice pouches. Three possible reasons why the bags were made by upcycling are that the juice pouches could be used without undergoing processing, upcycling reduces the volume of waste going to landfills, and the juice pouches are colourful and attractive.

117. Answers may vary. Sample answer: The risks of using insect repellents that contain DEET include the damage it can cause to materials such as plastics, some fabrics, and paints. DEET can also cause seizures. The benefits include the health benefits of keeping potentially harmful insects away.

118. If you were to run a small stream of water near a positively charged comb, the water will curve toward the comb. The negatively charged ends of the water molecules will be attracted to the positively charged comb.

119. Answers may vary. Sample answer: Three ways to represent various entities and how they form compounds include Lewis structures, structural formulas, and molecular models. A benefit of Lewis structures is that they show the number of valence electrons in an atom or ion and how different elements can share valence electrons to form stable molecules. Structural formulas show which atoms are bonded to which other atoms, and often this can be used to deduce the approximate shape of the molecule. Molecular models help us to visualize what a molecule might look like in three dimensions.

120. Impurities affect the freezing point, boiling point, and surface tension of water because the impurities interfere with the hydrogen bonds in water.

121. (a) Some uses of benzene are in the production of other chemicals and products, as an industrial solvent, and as an additive to gasoline.

(b) Some of the risks associated with the production of benzene are that exposure to benzene can cause serious diseases, such as cancer, as well as birth defects. Benzene is particularly related to leukemia because of the negative effect benzene has on bone marrow.

(c) Those who produce, transport, and use benzene are responsible for ensuring that it is handled and disposed of safely. Because of the carcinogenic effect of benzene, workers at benzene production plants and those who transport benzene must be protected from exposure to the chemical. The chemical must be contained and disposed of in such a way that it does not damage human health or is not accidentally released into the environment.

122. (a) Copper(I) chloride is a white crystal that is used in making fungicides and other organic compounds. Copper(II) chloride is blue-green in colour and is used as a catalyst in certain chemical reactions.

(b) The Cr^{3+} ion is sometimes called trivalent chromium (+3) and Cr^{6+} is called hexavalent chromium (+6). Hexavalent chromium is most common in the chromate ion, CrO_4^{2-} , and the dichromate ion, $\text{Cr}_2\text{O}_7^{2-}$. Trivalent chromium is necessary in the human body for sugar metabolism. It is toxic in large amounts. Hexavalent chromium is both toxic and carcinogenic.

(c) A former medical use of mercury was in thermometers, but mercury thermometers are rarely used now because of the danger of breakage. A former medical use of mercury(I) chloride was as a diuretic and laxative. A former medical use of mercury(II) chloride was as a treatment for syphilis. Mercury-containing materials were also used to treat constipation, depression, and toothaches. Some vaccines have contained mercury compounds as preservatives.

123. (a) The BC Cancer Agency (BCCA) is producing an isotope of fluorine: F-18.

(b) F-18 is needed for conducting PET scans. These scans are valuable in assessing the progression of cancer.

(c) The BCCA recently built a new cyclotron, which enables it to make its own supply of F-18.

(d) Having its own cyclotron will enable BCCA to conduct twice as many PET scans, diagnosing many more problems that can then be treated. It also frees up the cyclotron formerly used to produce BCCA's F-18 for other uses, such as making radioisotopes used to study neurological disorders like Parkinson's disease and Alzheimer's disease.

124. (a) Yttrium is named after Ytterby, Sweden, which is the site of quarries that contain many unusual elements that are not commonly found in other places. Yttrium was first found near Ytterby.

(b) Uranium is named for the planet Uranus, which was discovered at approximately the same time as uranium was discovered.

(c) Lawrencium is named after physicist Ernest O. Lawrence, who invented the cyclotron. This element was first synthesized at the Lawrence Berkeley National Laboratory of the University of California. This lab was founded by Ernest Lawrence and was named after him after his death.

(d) Ruthenium is derived from the Latin word *Ruthenia*, which means "Russia," where the element was discovered.

(e) Curium, a radioactive element, was named after Marie and Pierre Curie, who were early pioneers in the study of radioactivity.

125. (a) Raymond Lemieux and a colleague were the first people to artificially produce sucrose. His work on oligosaccharides helped develop drugs to reduce the chance of tissue rejection in transplant recipients. Lemieux started up several biotechnology companies in Canada.

(b) Canada, England, the United States, Saudi Arabia, and Sweden have honoured Lemieux. Canadian awards include Companion of the Order of Canada.

(c) The word "oligosaccharide" is derived from the Greek word *oligos*, meaning "a few," and from the Greek word *sacchar*, which means "sugar." The complex oligosaccharide molecule is formed from a few smaller sugar molecules bonded together.

126. (a) The poles of a magnet are called the north pole and the south pole. They were given these names because the north pole of a magnet is attracted to Earth's North Magnetic Pole. The south pole of a magnet points to Earth's South Magnetic Pole. The north poles of two magnets repel each other, as do the south poles. However, a north pole and a south pole attract each other.

(b) Electrically charged objects with like charges repel each other. A positively charged object is attracted to a negatively charged object.

(c) The terms “pole” and “polar” apply to both magnets and electrically charged items because both types of items have ends that exhibit electrical or magnetic polarity.

(d) In liquid water, the negative ends of the water molecules will be attracted to the positive ends of other water molecules. The like ends of the molecules will repel each other.

127. (a) Approximately half of the raw material for bioplastics comes from plant starch.

Currently, most of this starch comes from corn, but other starches, such as potato starch, are growing in popularity.

(b) Traditional plastics are considered to be non-biodegradable because they will not biodegrade in a reasonable amount of time. Even if they do eventually break down, they take much longer to biodegrade than do bioplastics.

(c) Besides microbes, factors that will biodegrade plastics include oxygen and ultraviolet light.

(d) Bioplastics can have an advantage over other plastics in the field of medicine because they can be made into capsules that will dissolve easily. Inserts made from bioplastics will dissolve on their own without having to be surgically removed.

(e) Answers may vary. Sample answer: One way to use bioplastics in agriculture would be by coating fields with a bioplastic that contains seeds, fertilizer, or pesticides. The bioplastic would degrade in the field and would not have to be removed.