TT TEXTBOOK TESTBANKS

Solutions Manual for Chemistry in Context 10th American Chemical Society

SOLUTIONS MANUAL SAMPLE PREVIEW

PUBLISHER
McGraw-Hill

COPYRIGHT
2021

RESOURCE TYPE
Solutions Manual

ISBN
9781260240849

ANSWERS TO
END-OF-CHAPTER QUESTIONS

CHAPTER 1: Portable Electronics: The Periodic Table in the Palm of Your Hand

Emphasizing Essentials

1. Answer:

a. Compound (2 molecules of one compound made up of two different elements).
b. Mixture (2 atoms of one element plus 2 atoms of another).
c. Mixture (~~three~~ 3 different substances, two elements and one compound).
d. Element (4 atoms of the same element).

2. Answer:

Formatted: Font: Bold, Complex Script Font: Bold

a. element (4 molecules of one diatomic element)
b. ~~C~~compound (2 molecules of one compound made up of two different elements).

Formatted: Font: Bold, Complex Script Font: Bold

c. Mixture (2 atoms of one element plus 2 atoms of another).

Formatted: Font: Bold, Complex Script Font: Bold

d. Compound (4 molecules of one compound made up of two different elements).

Formatted: Font: Bold, Complex Script Font: Bold

~~2. **Answer:**~~
~~Answers will vary widely but could include food, drink, furniture, books, and appliances, among others. Examples of homogeneous mixtures may be air (nitrogen, N_2, oxygen, O_2, argon, Ar, etc.), Gatorade (water, H_2O, sucrose, $C_{12}H_{22}O_{11}$, sodium chloride, NaCl, citric acid, $C_6H_8O_7$, etc.), and glass (silicon dioxide, SiO_2, sodium oxide, Na_2O, calcium oxide, CaO, aluminum oxide, Al_2O_3, etc.). Examples of heterogeneous mixtures include books (cellulose, $(C_6H_{10}O_5)_n$, carbon black, C, titanium oxide, TiO_2, polyvinyl acetate, $(C_4H_6O_2)_n$, etc.), granola bar (sucrose, $C_{12}H_{22}O_{11}$, sodium chloride, NaCl, baking soda, $NaHCO_3$, etc.), and a banana (water, H_2O, glucose, $C_6H_{12}O_6$, fructose, $C_6H_{12}O_6$, isoamyl acetate, $C_7H_{14}O_2$, etc.)~~

3. Answer: Exact answer will vary depending on viewing size of text. An approximate measurement for the period could be 0.25 mm. Converting this to nanometers: 0.25 mm × $\frac{10^{-3}\text{ m}}{1\text{ mm}} \times \frac{1\text{ nm}}{10^{-9}\text{ m}} = 2.5\times10^{5}$ nm or 250,000 nm.

4. Answer:

Formatted: Font: Bold, Complex Script Font: Bold

Converting 10.0 nanometers to millimeters: $10.0\text{ nm} \times \frac{1\text{ m}}{1\times10^{9}\text{ nm}} \times \frac{1000\text{ mm}}{1\text{ m}} = 1\times10^{-5}\text{ mm}$ or 0.00001 mm.

45. Answer:
a. 1.5×10^{3} m

b. 9.58×10^{-11} m
c. 7.5×10^{-6} m

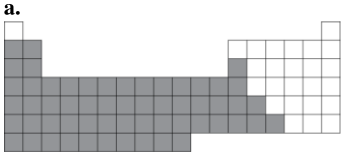
~~5~~6. Answer: $1{\times}10^{2}$cm, $1{\times}10^{6}$µm, $1{\times}10^{9}$nm.

Formatted: Font: Bold, Complex Script Font: Bold

~~6~~7. Answer:
a. Group 1~~A~~ and Group 17~~7A~~
b. 1A: lithium, sodium, potassium, rubidium, cesium, francium
7A: fluorine, chlorine, bromine, iodine, astatine
c. 1A: All but hydrogen (a nonmetal) are reactive metals.
7A: All but astatine (a metalloid) are reactive nonmetals.

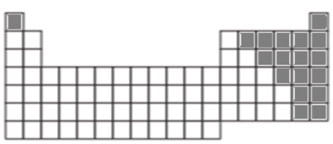
~~7~~8. **Answer:**

a.



b. iron, Fe; magnesium, Mg; aluminum, Al; sodium, Na; potassium, K; silver, Ag.

c.



d. sulfur, S; oxygen, O, carbon, C, chlorine, Cl, fluorine, F (and others).

Formatted: Font: Bold, Complex Script Font: Bold

~~8.~~9. Answer:

a. compound	**b.** compound	**c.** mixture
d. element	**e.** mixture	**f**. element

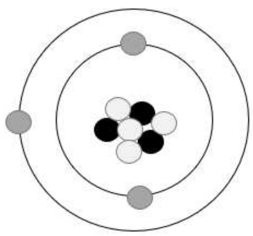
10. Answer:

a. heterogenous mixture	**b.** heterogenous mixture	**c.** heterogenous mixture
d. homogenous mixture	**e.** heterogenous mixture	

Commented [SR1]: Could someone check me on this one? I could go either way on it, depends on how well it is mixed!

11. Answer:

Formatted: Font: Bold, Complex Script Font: Bold



Grey spheres: electrons

Black spheres: protons

White spheres: neutrons

~~9~~12. Answer: There are several allotropes of sulfur. The most stable and common allotrope consists of 8 atoms in a ring. Other common allotropes include rings of 5, 6, 7, 10 and larger number of atoms. Most allotropes are yellow solids, although they can be found in liquid or gaseous forms at appropriate temperatures. Most of these allotropes are created by heating sulfur of the 8-membered ring form.

Formatted: Font: Bold, Complex Script Font: Bold

~~10~~13. Answer:
An aluminum atom with mass number 27 has 13 protons, 14 neutrons, and 13 electrons. ~~When oxidized to a +3 ion, the number of electrons drops down to 10, but the number of protons and neutrons remains the same. A S^{2-} ion with mass number of 32 has 16 protons, 16 neutrons, and 18 electrons.~~

14. Answer:

A copper atom with a mass number 64 has 29 protons, 35 neutrons, and 29 electrons.

15. Answer:

Electrical conductivity is the transport of electrons from one location to another. Thermal conductivity is the transfer of heat from one location to another. Their difference is in what is being transferred.

16. Answer:

~~**12. Answer:**~~

a. $\frac{\text{mass of Hf}}{\text{total mass of Hf+O's}} = \frac{178.5 \text{ g/mol}}{(178.5 \text{ g/mol})+(16.00 \text{ g/mol})(2)} \times 100\% = 84.80\% \text{ Hf}$

$\frac{\text{mass of O's}}{\text{total mass of Hf+O's}} = \frac{(16.00 \text{ g/mol})(2)}{(178.5 \text{ g/mol})+(16.00 \text{ g/mol})(2)} \times 100\% = 15.20\% \text{ O}$

$$\text{b. } \frac{\text{mass of Be}}{\text{total mass of Be+Cl's}} = \frac{9.012\text{ g/mol}}{(9.012\text{ g/mol})+(35.45\text{ g/mol})(2)} \times 100\% = 11.28\%\text{ Be}$$

$$\frac{\text{mass of Cl's}}{\text{total mass of Be+Cl's}} = \frac{(35.45\text{ g/mol})(2)}{(9.012\text{ g/mol})+(35.45\text{ g/mol})(2)} \times 100\% = 88.72\%\text{ Cl}$$

$$\text{c. } \frac{\text{mass of Ti}}{\text{total mass of Ti+O's+H's}} = \frac{47.88\text{ g/mol}}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 41.31\%\text{ Ti}$$

$$\frac{\text{mass of O's}}{\text{total mass of Ti+O's+H's}} = \frac{(16.00\text{ g/mol})(4)}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 55.22\%\text{ O}$$

$$\frac{\text{mass of H's}}{\text{total mass of Ti+O's+H's}} = \frac{(1.008\text{ g/mol})(4)}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 3.478\%\text{ H}$$

$$\text{d. } \frac{\text{mass of Fe}}{\text{total mass of Fe+O}} = \frac{55.85\text{ g/mol}}{(55.85\text{ g/mol})+(16.00\text{ g/mol})} \times 100\% = 77.73\%\text{ Fe}$$

$$\frac{\text{mass of O}}{\text{total mass of Fe+O}} = \frac{16.00\text{ g/mol}}{(55.85\text{ g/mol})+(16.00\text{ g/mol})} \times 100\% = 22.27\%\text{ O}$$

$$\text{e. } \frac{\text{mass of Si}}{\text{total mass of Si+O's}} = \frac{28.09\text{ g/mol}}{(28.09\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 46.75\%\text{ Si}$$

$$\frac{\text{mass of O's}}{\text{total mass of Si+O's}} = \frac{(16.00\text{ g/mol})(2)}{(28.09\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 53.25\%\text{ O}$$

$$\text{f. } \frac{\text{mass of B}}{\text{total mass of B+O's+H's}} = \frac{10.81\text{ g/mol}}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 17.48\%\text{ B}$$

$$\frac{\text{mass of O's}}{\text{total mass of B+O's+H's}} = \frac{(16.00\text{ g/mol})(3)}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 77.63\%\text{ O}$$

$$\frac{\text{mass of H's}}{\text{total mass of B+O's+H's}} = \frac{(1.008\text{ g/mol})(3)}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 4.891\%\text{ H}$$

Formatted: List Paragraph, Indent: Before: 0", Line spacing: 1.5 lines

~~11. **Answer: a.** ionic **b.** molecular **c.** molecular **d.** ionic **e.** molecular~~

Formatted: Indent: Before: 0"

~~**12. Answer:**~~

Formatted: Font: (Default) Times New Roman, Bold, Font color: Text 1, Complex Script Font: Times New Roman, Bold

Formatted: Normal

Formatted: Normal, Space Before: 0 pt, After: 0 pt, Line spacing: single

$$\cancel{\text{a. } \frac{\text{mass of Hf}}{\text{total mass of Hf+O's}} = \frac{178.5\text{ g/mol}}{(178.5\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 84.80\%\text{ Hf}}$$

$$\cancel{\frac{\text{mass of O's}}{\text{total mass of Hf+O's}} = \frac{(16.00\text{ g/mol})(2)}{(178.5\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 15.20\%\text{ O}}$$

$$\cancel{\text{b. } \frac{\text{mass of Be}}{\text{total mass of Be+Cl's}} = \frac{9.012\text{ g/mol}}{(9.012\text{ g/mol})+(35.45\text{ g/mol})(2)} \times 100\% = 11.28\%\text{ Be}}$$

$$\cancel{\frac{\text{mass of Cl's}}{\text{total mass of Be+Cl's}} = \frac{(35.45\text{ g/mol})(2)}{(9.012\text{ g/mol})+(35.45\text{ g/mol})(2)} \times 100\% = 88.72\%\text{ Cl}}$$

$$\cancel{\text{c. } \frac{\text{mass of Ti}}{\text{total mass of Ti+O's+H's}} = \frac{47.88\text{ g/mol}}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 41.31\%\text{ Ti}}$$

$$\cancel{\frac{\text{mass of O's}}{\text{total mass of Ti+O's+H's}} = \frac{(16.00\text{ g/mol})(4)}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 55.22\%\text{ O}}$$

~~$\frac{\text{mass of H's}}{\text{total mass of Ti+O's+H's}} = \frac{(1.008\text{ g/mol})(4)}{(47.88\text{ g/mol})+(16.00\text{ g/mol})(4)+(1.008\text{ g/mol})(4)} \times 100\% = 3.478\%\text{ H}$~~

~~d. $\frac{\text{mass of Fe}}{\text{total mass of Fe+O}} = \frac{55.85\text{ g/mol}}{(55.85\text{ g/mol})+(16.00\text{ g/mol})} \times 100\% = 77.73\%\text{ Fe}$~~

~~$\frac{\text{mass of O}}{\text{total mass of Fe+O}} = \frac{16.00\text{ g/mol}}{(55.85\text{ g/mol})+(16.00\text{ g/mol})} \times 100\% = 22.27\%\text{ O}$~~

~~e. $\frac{\text{mass of Si}}{\text{total mass of Si+O's}} = \frac{28.09\text{ g/mol}}{(28.09\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 46.75\%\text{ Si}$~~

~~$\frac{\text{mass of O's}}{\text{total mass of Si+O's}} = \frac{(16.00\text{ g/mol})(2)}{(28.09\text{ g/mol})+(16.00\text{ g/mol})(2)} \times 100\% = 53.25\%\text{ O}$~~

~~f. $\frac{\text{mass of B}}{\text{total mass of B+O's+H's}} = \frac{10.81\text{ g/mol}}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 17.48\%\text{ B}$~~

~~$\frac{\text{mass of O's}}{\text{total mass of B+O's+H's}} = \frac{(16.00\text{ g/mol})(3)}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 77.63\%\text{ O}$~~

~~$\frac{\text{mass of H's}}{\text{total mass of B+O's+H's}} = \frac{(1.008\text{ g/mol})(3)}{(10.81\text{ g/mol})+(16.00\text{ g/mol})(3)+(1.008\text{ g/mol})(3)} \times 100\% = 4.891\%\text{ H}$~~

Formatted: Normal, Space Before: 0 pt, After: 0 pt

~~13~~17. **Answer:**

Formatted: Font: Bold, Complex Script Font: Bold

a. 1 carbon atom (nonmetal), 2 oxygen atoms (nonmetals)
b. 2 hydrogen atoms (nonmetals), 1 sulfur atom (nonmetal)
c. 1 nitrogen atom (nonmetal), 2 oxygen atoms (nonmetals)
d. 1 silicon atom (metalloid), 2 oxygen atoms (nonmetals)

~~**14. Answer:**~~
~~Since the density of the solid is greater than pure water (approximately 1.00 g/cm^3, depending on the temperature), the solid will sink when placed in pure water.~~

Formatted: Indent: Before: 0"

~~15. **Answer: a.** copper has a +2 oxidation state; **b.** aluminum has a +3 oxidation state; **c.** iron has a +3 oxidation state; **d.** manganese has a +7 oxidation state~~

Concentrating on Concepts

~~16~~18. **Answer:**

A variety of answers are possible. An example of an illustration of 9N purity is the time span of 1 second compared to 31.7 years. A similar example with 12 N purity is 1 second compared to 31,700 years. A volume-related example of 9N purity would be like taking 1 liter of water out of 400 Olympic-sized swimming pools full of water!

19. Answer:

Formatted: Font: Bold, Complex Script Font: Bold

Answers will vary widely but could include food, drink, furniture, books, and appliances, among others. Examples of homogeneous mixtures may be air (nitrogen, N_2, oxygen, O_2, argon, Ar, etc.), Gatorade (water, H_2O, sucrose, $C_{12}H_{22}O_{11}$, sodium chloride, NaCl, citric acid, $C_6H_8O_7$, etc.), and glass (silicon dioxide, SiO_2, sodium oxide, Na_2O, calcium oxide, CaO, aluminum oxide, Al_2O_3, etc.). Examples of heterogeneous mixtures include books (cellulose, $(C_6H_{10}O_5)_n$, carbon black, C, titanium oxide, TiO_2, polyvinyl acetate, $(C_4H_6O_2)_n$, etc.), granola bar (sucrose, $C_{12}H_{22}O_{11}$, sodium chloride, NaCl, baking soda, $NaHCO_3$, etc.), and a banana (water, H_2O, glucose, $C_6H_{12}O_6$, fructose, $C_6H_{12}O_6$, isoamyl acetate, $C_7H_{14}O_2$, etc.)

20~~7~~. **Answer:** Answers will vary, depending on year selected. As of 2019~~16~~, the latest technology node is 5 nm, which features a gate length of around 10 nm (https://en.wikichip.org/wiki/5_nm_lithography_process).

Formatted: Font: Bold, Complex Script Font: Bold

~~smallest transistors used in electronics devices have features of 14 nm.~~ This is equivalent to

$104\ \text{nm}\times\frac{10^{-9}\ \text{m}}{1\ \text{nm}}\times\frac{1\ \text{km}}{10^{3}\ \text{m}} = 1.04\times10^{-11}\ \text{km}.$

21. Answer:

The periodic table allowed gaps for unknown elements. The elements were placed into gaps based on their atomic weight and number of protons.

22. Answer:

~~t~~There are many steps involved during this process. Many resources are available on the Internet that describe this process (e.g., http://www.australianminesatlas.gov.au/education/fact_sheets/aluminium.html)

23. Answer:

Sapphire is about three times as hard as Gorilla glass but is about 67% more dense. This means that although sapphire could greater resist scratches, a similar sized piece would weigh more than a piece of Gorilla glass. Gorilla glass has an amorphous structure composed primarily of silicon and oxygen atoms with other minority component atoms. Sapphire is a single crystal of aluminum and oxygen atoms. Both materials require high temperature melting of raw materials followed by slow cooling. Gorilla glass requires another heating step in a molten bath of salts. Sapphire requires a much higher temperature melt. Regular glass is also amorphous & is composed primarily of silicon and oxygen atoms with additives of sodium and calcium oxides. A comprehensive website that quantitatively compares the physical and optical properties of typical soda-lime glass, Gorilla glass, and quartz is found at:

http://abrisatechnologies.com/specs/AT%20Specialty%20Glass%20Technical%20Capabilities%20Brochure.pdf

Formatted: Font: (Default) Times New Roman, 12 pt, Font color: Text 1, Complex Script Font: Times New Roman, 12 pt

Formatted: Normal

24. Answer:

A thin layer of a transparent conducting material is deposited on the surface of glass. The most common material used for this purpose is indium tin oxide (ITO), which is used in applications ranging from LED displays to solar cells. Do-it-yourself enthusiasts have posted to the internet a way to coat glass using stannous chloride ($SnCl_2$) to create a layer of conductive tin oxide.

25. Answer:

When the surface of glass cools quickly in a Prince Rupert's drop, silicon and oxygen atoms form tight bonds that hold the material into shape. The silicon and oxygen atoms within the drop are still semi-mobile while the outer surface is hardening. When the interior of the drop cools, new bonds between silicon and oxygen form, pulling them tighter together. However, since the other layer of glass is held tightly in place, the atoms on the interior are not able to approach each other as close as optimal, resulting in internal stress. When some of the bonds between silicon and oxygen atoms in the surface of the glass are broken, the internal bonds are pulled tightly together with enough strength to further break additional bonds in the outer layer. This results in the shattering of the drop as bonds throughout the glass break or shrink.

Formatted: Font: (Default) Times New Roman, Complex Script Font: Times New Roman

26. Answer:

Answers will vary depending on device and component choice, but typical components and sizes include length (e.g. 14.5 cm, 145 mm, 145,000 μm, 145,000,000 nm); width (e.g. 7.5 cm, 75 mm, 75,000 μm, 75,000,000 nm); thickness (e.g. 1 cm, 10 mm, 10,000 μm, 10,000,000 nm); camera lens (e.g. 0.3 cm, 3 mm, 3,000 μm, 3,000,000 nm); and speaker hole diameter (e.g. 0.03 cm, 0.3 mm, 300 μm, 300,000 nm).

27. Answer:

The list of metals used in cell phones that are common in Earth's crust includes: aluminum, iron, potassium, magnesium, titanium, manganese, barium, and nickel. They are found in ores, minerals, and compounds.

28. Answer:

A transparent material allows light to travel through it without refracting. Having a transparent screen keeps the light produced from distorting when you look at it. Additives can give solids like glass a different color or other properties like strength. Heat treatment can also add durability.

Commented [SR2]: The book doesn't really go into depth on this. How much do they need to go in depth on it?

29. Answer:

Gold prospectors can use panning to separate gold flakes from other solids. This involves taking the mixture and agitating it in water. This separates out the gold because it stays in the bottom of the pan and other substances float in the water and can be poured out.

30. Answer:

The steps involved to convert silica sand, mostly composed of SiO_2, to high-purity Si are outlined in Section 1.8. In contrast, sea sand contains many impurities such as metals (*e.g.*, Fe, Al, Mg, K, Na, Ca, Zn, Ni, etc.) and nonmetals (*e.g.*, B, P) that would require extensive pre-processing of the sand via chemical reactions, involving acids and high temperatures. Furthermore, the use of sea sand for industrial processes would not be sustainable and would cause a variety of environmental consequences. By disturbing sea sand, an area could be changed physically, biologically, and chemically.

31. Answer:

Waste products of high-purity silicon include carbon monoxide (from reduction of the silicon), carbon dioxide (from combustion heating), compounds containing the impurities (including phosphorous, boron, and a variety of metals), and waste heat.

32. Answer:

While individual cell phones may become smaller and take up less space in, say, a landfill, there may be a much higher impact on the environment, depending on the materials required for making the cell phone and the energy needed for manufacturing the components. To make the devices smaller and less expensive, different materials may be used, which may require more invasive mining or greater waste production in the manufacturing process.

33. Answer:

Answers will vary according to relative weighing of factors. The grade for the "Environmental" pillar should consider the production and recycling of waste and the relative use of limited natural resources, including rare earth metals. The grade for the "Social" pillar should include both the impact of portable electronics on the quality of life of consumers as well as the impact on the lives of workers in the mining of raw materials, manufacturing of the products, and those that live in the regions impacted by mining and manufacturing. The grade for "Economic" pillar should consider the wealth generated by the mining, manufacturing, and sale of these electronics and how this wealth is distributed.

Formatted: Font: (Default) Times New Roman, Complex Script Font: Times New Roman

Formatted: List Paragraph, Indent: Before: 0", Space Before: 0 pt, After: 0 pt

~~**18. Answer:**~~

~~Gordon Moore, one of the founders of the computer chip maker Intel, predicted in 1965 that the number of transistors per square inch on integrated circuits would double every 12 months. In 1975, he revised his prediction to double every 24 months. This prediction has held true through at least 2016. However, both Moore and current Intel CEO Brian Krzanich have recently suggested that chip makers may reach physical and economic limitations to this growth within the next 5-10 years.~~

~~19. **Answer:** there are many steps involved during this process. Many resources are available on the Internet that describe this process (e.g., http://www.australianminesatlas.gov.au/education/fact_sheets/aluminium.html)~~

~~**20. Answer:**~~

~~Sapphire is about three times as hard as Gorilla glass but is about 67% more dense. This means that although sapphire could greater resist scratches, a similar sized piece would weigh more than a piece of Gorilla glass. Gorilla glass has an amorphous structure composed primarily of silicon and oxygen atoms with other minority component atoms. Sapphire is a single crystal of aluminum~~

~~and oxygen atoms. Both materials require high temperature melting of raw materials followed by slow cooling. Gorilla glass requires another heating step in a molten bath of salts. Sapphire requires a much higher temperature melt.~~

21. ~~**Answer:**~~ ~~A thin layer of a transparent conducting material is deposited on the surface of glass. The most common material used for this purpose is indium tin oxide (ITO), which is used in applications ranging from LED displays to solar cells. Do-it-yourself enthusiasts have posted to the internet a way to coat glass using stannous chloride ($SnCl_2$) to create a layer of conductive tin oxide.~~

~~**22. Answer:**~~

~~When the surface of glass cools quickly in a Prince Rupert's drop, silicon and oxygen atoms form tight bonds that hold the material into shape. The silicon and oxygen atoms within the drop are still semi-mobile while the outer surface is hardening. When the interior of the drop cools, new bonds between silicon and oxygen form, pulling them tighter together. However, since the other layer of glass is held tightly in place, the atoms on the interior are not able to approach each other as close as optimal, resulting in internal stress. When some of the bonds between silicon and oxygen atoms in the surface of the glass are broken, the internal bonds are pulled tightly together with enough strength to further break additional bonds in the outer layer. This results in the shattering of the drop as bonds throughout the glass break or shrink.~~

23. ~~**Answer:**~~ ~~Answers will vary depending on device and component choice, but typical components and sizes include length (e.g. 14.5 cm, 145 mm, 145,000 μm, 145,000,000 nm); width (e.g. 7.5 cm, 75 mm, 75,000 μm, 75,000,000 nm); thickness (e.g. 1 cm, 10 mm, 10,000 μm, 10,000,000 nm); camera lens (e.g. 0.3 cm, 3 mm, 3,000 μm, 3,000,000 nm); and speaker hole diameter (e.g. 0.03 cm, 0.3 mm, 300 μm, 300,000 nm).~~

~~**24. Answer:**~~

~~The list of metals used in cell phones that are common in Earth's crust includes: aluminum, iron, potassium, magnesium, titanium, manganese, barium, and nickel.~~

25. ~~**Answer:**~~

~~The steps involved to convert silica sand, mostly composed of SiO_2, to high-purity Si are outlined in Section 1.8. In contrast, sea sand contains many impurities such as metals (*e.g.*, Fe, Al, Mg, K, Na, Ca, Zn, Ni, etc.) and nonmetals (*e.g.*, B, P) that would require extensive pre-processing of the sand via chemical reactions, involving acids and high temperatures. Furthermore, the use of sea sand for industrial processes would not be sustainable and would cause a variety of environmental consequences. By disturbing sea sand, an area could be changed physically, biologically, and chemically.~~

~~**26. Answer:**~~

~~Waste products of high-purity silicon include carbon monoxide (from reduction of the silicon), carbon dioxide (from combustion heating), compounds containing the impurities (including phosphorous, boron, and a variety of metals), and waste heat.~~

27. **Answer:** ~~While individual cell phones may become smaller and take up less space in, say, a landfill, there may be a much higher impact on the environment, depending on the materials required for making the cell phone and the energy needed for manufacturing the components. To make the devices smaller and less expensive, different materials may be used, which may require more invasive mining or greater waste production in the manufacturing process.~~

~~**28. Answer:**~~
~~Answers will vary according to relative weighing of factors. The grade for the "Environmental" pillar should consider the production and recycling of waste and the relative use of limited natural resources, including rare earth metals. The grade for the "Social" pillar should include both the impact of portable electronics on the quality of life of consumers as well as the impact on the lives of workers in the mining of raw materials, manufacturing of the products, and those that live in the regions impacted by mining and manufacturing. The grade for "Economic" pillar should consider the wealth generated by the mining, manufacturing, and sale of these electronics and how this wealth is distributed.~~

Exploring Extensions

~~29~~34. Answer:
Gordon Moore, one of the founders of the computer chip maker Intel, predicted in 1965 that the number of transistors per square inch on integrated circuits would double every 12 months. In 1975, he revised his prediction to double every 24 months. This prediction has held true through at least 2016. However, both Moore and current Intel CEO Brian Krzanich have recently suggested that chip makers may reach physical and economic limitations to this growth within the next 5-10 years.

Formatted: Font: Bold, Complex Script Font: Bold

Formatted: List Paragraph, Indent: Before: 0"

35. Answer:
The colors of many gemstones come~~s~~ from impurities in the crystal structure. For example, the purple color of amethyst comes from Fe^{3+} ~~iron (III)~~ ions in a SiO_2 crystal, and the red color of rubies comes from Cr^{3+} ~~chromium (III)~~ in an Al_2O_3 crystal.

Formatted: Font: Bold, Complex Script Font: Bold

Formatted: Superscript

Formatted: Superscript

~~30~~36. Answer:
Impurities break up the crystal structure of crystalline solids and, since properties of materials are in part dependent on structure, this will change the material properties. Throughout this chapter, we have seen impurities that change properties such as color, transparency, melting point, and electrical conductivity.

~~31~~37. Answer: A thin layer of material is sandwiched between two pieces of glass. When an electrical current is passed through the glass, the material will line up according to the direction of the current, similar the liquid crystal display (LCD) of common calculators.

Formatted: Font: Bold, Complex Script Font: Bold

~~32~~38. Answer:
Devices can be physically pulled apart to reveal the components containing the metals. Plastic parts such as circuit boards are either dissolved in solvent or burned to isolate the metallic components. These metals themselves may be either melted or dissolved in acids and then filtered and reconstituted to generate purer forms of the metal for other uses. A recent report describes the use of fungi to extract precious metals from electronic waste, a potentially more environmentally ~~-~~friendly way of recycling.

~~33~~39. Answer: Apple has removed mercury and arsenic from screens and lead from solder in their electronics.

Formatted: Font: Bold, Complex Script Font: Bold

Formatted: Font: Not Bold, Complex Script Font: Not Bold

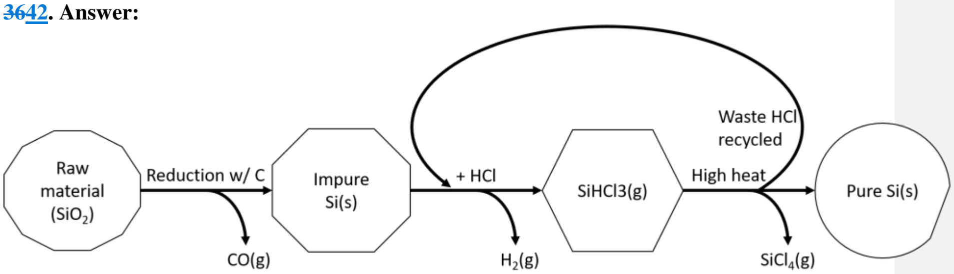
Formatted: Font: Not Bold, Complex Script Font: Not Bold

~~34~~40. Answer:
The two largest destinations for electronic waste in the world are in New Dehli, India, and Guiyu, China. Studies have shown air, water, and soil pollution from electronics recycling around Guiyu leading to poisoning from heavy metals such as lead and organic pollutants such as dioxins. To prevent these situations, new methods of recycling need to be developed with greater safety awareness for workers, tighter controls on emissions from recycling centers, and redesign of the electronic devices to reduce toxic components.

~~35~~41. Answer: Old electronic devices could be disassembled and either parts could be reused as is or could be mechanically or chemically separated into raw materials to be used for manufacturing new devices.

Formatted: Font: Bold, Complex Script Font: Bold

~~36~~42. Answer:



The H_2 and $SiCl_4$ gases are recycled through reaction to generate chlorosilanes that are used to purify the Si in earlier steps. However, CO is released, which is further oxidized to CO_2, a greenhouse gas.

43. Answer:

Answers will vary as there are many ways to strengthen glass. This may include heating the glass or adding different elements into the structure.

44. Answer:

There were 46.89 million iPhones sold in 2018. 25% of this is 11.72 million. An iPhone 8 has a mass of 202 grams. 24% of ~~an~~ the mass of an iPhone is Al, so one~~1~~ phone has 48.48 grams. This multiplied by 11.72 million iPhones is 5.68×10^5 kg. Copper is 6% of the mass of an iPhone, which is 12.12 grams per iPhone. This multiplied by 11.72 million iPhones is 1.42×10^5 kg. Cobalt is 5% of the mass of an iPhone, which is 10.1 grams per iPhone. This multiplied by 11.72 million iPhones is 1.18×10^5 kg. Each iPhone contains 300 mg of silver, multiplied by 11.72 million is 3516 kg of silver. Each iPhone contains 30 mg of gold, multiplied by 11.72 million is 351.6 kg. At current pricing, this yields:
Al: $1,949,376, Cu: $862,224, Co: $4,062,740, Ag: $1,913,196, Au: $16,598,779=$25,386,315.

45. Answer:

refer back to Figure 1.2~~7~~4. A cradle-to-cradle scenario would include recycling of metals, plastics, etc. in the phone back into a useful end product.

46. Answer:

Some considerations include toxicity of materials used in the device, availability of raw materials, amount of energy required by the device, and number of uses for the device and disposable components (such as batteries).

47. Answer:

To extract aluminum from ore, bauxite is crushed and dissolved in a solution of concentrated sodium hydroxide to remove aluminum oxide from the rest of the ore. The aluminum oxide-sodium hydroxide mixture is then neutralized and is mixed with sodium aluminum fluoride (cryolite). At high temperatures, a carbon electrode is used to reduce the aluminum oxide to molten aluminum. This process is very energy intensive and expensive.
Aluminum recycling involves collecting used aluminum, cleaning the metal, then melting the metal to remove any coating, and then cooling the metal to form solid aluminum. The recycling process uses high temperatures to melt the metal, but uses much less energy and is more cost efficient than extraction. Recycling uses more than 90 percent less energy than extraction from bauxite.

48. Answer:

The increase in demand for rare earth metals amounts to about 40%. Rare earth metals are used in a wide variety of products such as cell phones, computers, rechargeable batteries, wind turbines, speakers, and fluorescent lights. It is doubtful that the U.S. could meet its demand for rare earth elements even with 100% recovery of the metals. The growth of the market for this wide variety of products outpaces the retirement of old products, many of which may not use much if any rare earth metals that could be recycled.

Formatted: Font: Bold, Complex Script Font: Bold

~~**37. Answer:** a good web resource that compares CZ growth *vs.* the float zone technique is http://www.siliconsultant.com/SIcrysgr.htm. The Si ingots are sliced into an appropriate thickness and a variety of processing steps are then used to fabricate a processor chip. Intel provides details regarding these steps (http://download.intel.com/newsroom/kits/chipmaking/pdfs/Sand-to-Silicon_32nm-Version.pdf).~~

~~**38. Answer:** refer back to Figure 1.27. A cradle-to-cradle scenario would include recycling of metals, plastics, etc. in the phone back into a useful end product.~~

~~39. **Answer:** Some considerations include toxicity of materials used in the device, availability of raw materials, amount of energy required by the device, and number of uses for the device and disposable components (such as batteries).~~

~~**40. Answer:**~~

~~To extract aluminum from ore, bauxite is crushed and dissolved in a solution of concentrated sodium hydroxide to remove aluminum oxide from the rest of the ore. The aluminum oxide-sodium hydroxide mixture is then neutralized and is mixed with sodium aluminum fluoride (cryolite). At high temperatures, a carbon electrode is used to reduce the aluminum oxide to molten aluminum. This process is very energy intensive and expensive.~~

~~Aluminum recycling involves collecting used aluminum, cleaning the metal, then melting the metal to remove any coating, and then cooling the metal to form solid aluminum. The recycling process uses high temperatures to melt the metal, but uses much less energy and is more cost efficient than extraction. Recycling uses more than 90 percent less energy than extraction from bauxite.~~

~~41. **Answer:** The increase in demand for rare earth metals amounts to about 40%. Rare earth metals are used in a wide variety of products such as cell phones, computers, rechargeable batteries, wind turbines, speakers, and fluorescent lights. It is doubtful that the U.S. could meet its demand for rare earth elements even with 100% recovery of the metals. The growth of the market for this wide variety of products outpaces the retirement of old products, many of which may not use much if any rare earth metals that could be recycled.~~

Instructor's Guide – Investigation 1

CHEMICAL AND PHYSICAL CHANGES

ADDITIONAL SAFETY NOTES/WASTE DISPOSAL NOTES

If you choose to conduct a demonstration of elemental chlorine gas and sodium metal reacting together, take proper safety precautions. Sodium metal is extremely reactive with water and should be stored in mineral oil. Chlorine gas is very toxic and must be contained within a fume hood. Keep everyone away from the demonstration as it is extremely exothermic. Be sure that your container for the reaction is free of any cracks.

ESTIMATED TIME: 120 minutes

MATERIALS FOR 10 PAIRS OF STUDENTS

Materials

- Bar magnet
- Bunsen burner
- Watch glass
- Clear glass threaded vials with lids
- 100-mL graduated cylinder
- Dropper
- Small or medium test tubes
- Test tube rack
- Glass capillary melting point tubes
- Melting point apparatus
- Periodic table
- See A-11 for tips on using a Bunsen burner

Chemicals

- Element samples.
    - Aluminum shot
    - Antimony
    - Arsenic
    - Bismuth
    - Bromine water
    - Cadmium
    - Carbon charcoal
    - Carbon graphite
    - Chromium
    - Copper wire
    - Copper pellets
    - Germanium
    - Iodine crystals
    - Iron
    - Lead
    - Lithium
    - Magnesium
    - Manganese
    - Nickel
    - Selenium
    - Silicon
    - Sulfur
    - Tin
    - Zinc pellets
- Copper(II) sulfate
- Calcium carbonate
- Ethanol
- Hexane
- Acetone
- Methanol
- Propanol
- 2-propanol
- Lead(II) nitrate
- Potassium iodide
- Sodium chloride
- Sodium bicarbonate

- 0.5-M sodium carbonate
- 0.5-M sodium sulfate
- 1-M hydrochloric acid
- 0.5-M calcium nitrate
- 0.5-M copper(II) nitrate
- 1-M ammonium hydroxide
- If aqueous, indicate concentration
- If unknown is needed,
    - indicate its identity as a sub-bullet

PREPARATION TIPS

- To prepare 0.5-M sodium carbonate, add 52.98 grams of solid sodium carbonate to 1 L of water.
- To prepare 0.5-M sodium sulfate, add 70.97 grams of solid sodium sulfate to 1 L of water.
- To prepare 0.5-M calcium nitrate, add 82.04 grams of solid calcium nitrate to 1 L of water.
- To prepare 0.5-M copper(II) nitrate, add 93.78 grams of solid copper(II) nitrate to 1 L of water.
- Instead of obtaining each element separately, you could purchase an element kit such as: https://www.flinnsci.com/flinn-chemical-element-set/ap1128/#variantDetails

RELATED VIDEOS

- Video of chlorine gas and sodium chloride: https://www.youtube.com/watch?v=tbPxwDiX1NU
- Video of lead nitrate and potassium iodide: https://www.youtube.com/watch?v=81ZPLgFav00

OTHER NOTES/TROUBLESHOOTING

- For Reflection Question 1 about smartphone components, direct students to https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2014-2015/smartphones.html.
- For Reflection Question 2 about endangered elements, direct students to https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2014-2015/smartphones.html.

SAMPLE DATA

Reaction	Observations
Sodium carbonate + hydrochloric acid	Bubbling, gas produced (CO_2), and NaCl is aqueous
Sodium sulfate + hydrochloric acid	No reaction because all products are also aqueous
Calcium nitrate + ammonium hydroxide	No reaction
Copper(II) nitrate + ammonium hydroxide	Copper(II) hydroxide precipitates in a light blue color. Then turns deep blue.
Lead (II) nitrate + potassium iodide	Yellow crystals form