CHAPTER 3

ELEMENTS AND COMPOUNDS

SOLUTIONS TO REVIEW QUESTIONS

1. Silicon 25.7% Hydrogen 0.9%

In 100 g \( \frac{25.7 \text{ g Si}}{0.9 \text{ g H}} = 30 \text{ g Si/1 g H} \) (1 sig. fig.)

Si is 28 times heavier than H, thus since 30 > 28, there are more Si atoms than H atoms.

2. (a) Mn (c) Na (e) Cl (g) Zn
(b) F (d) He (f) V (h) N

3. (a) Iron (c) Carbon (e) Beryllium (g) Argon
(b) Magnesium (d) Phosphorus (f) Cobalt (h) Mercury

4. The symbol of an element represents the element itself. It may stand for a single atom or a given quantity of the element.

5. Na sodium K potassium Fe iron Sb antimony Sn tin
   Ag silver W tungsten Au gold Hg mercury Pb lead

6. H hydrogen B boron C carbon N nitrogen O oxygen F fluorine P phosphorus
   S sulfur K potassium V vanadium Y yttrium I iodine W tungsten U uranium

7. 1 metal 0 metalloids 5 nonmetals

8. Hydrogen \( \text{H}_2 \) Chlorine \( \text{Cl}_2 \)
   Nitrogen \( \text{N}_2 \) Bromine \( \text{Br}_2 \)
   Oxygen \( \text{O}_2 \) Iodine \( \text{I}_2 \)
   Fluorine \( \text{F}_2 \)

9. (a) \( \text{CO} \) – 1 atom of carbon and 1 atom of oxygen
(b) \( \text{H}_2 \) – 1 molecule of hydrogen
   (made of 2 atoms of hydrogen)
(c) \( \text{S}_8 \) – 1 molecule of sulfur (made of 8 atoms of sulfur)
(d) \( \text{CS} \) – 1 atom of carbon and 1 atom of sulfur
   Co – 1 atom of cobalt
   2 \( \text{H} \) – 2 atoms of hydrogen
   8 \( \text{S} \) – 8 atoms of sulfur
   Cs – 1 atom of cesium
10. In an element all atoms are alike, while a compound contains two or more elements (different atoms) which are chemically combined. Compounds can be decomposed into simpler substances while elements cannot.

11. 86 metals 7 metalloids 18 nonmetals (based on 111 elements)

12. 7 metals 1 metalloid 2 nonmetals

13. (a) iodine (b) bromine

14. A compound is composed of two or more elements which are chemically combined in a definite proportion by mass. Its properties differ from those of its components. A mixture is the physical combining of two or more substances (not necessarily elements). The composition may vary, the substances retain their properties, and they may generally be separated by physical means.

15. Molecular compounds exist as molecules formed from two or more atoms of elements bonded together. Ionic compounds exist as cations and anions held together by electrical attractions.

16. Compounds are distinguished from one another by their characteristic physical and chemical properties.

17. Cations are positively charged, while anions are charged negatively.
SOLUTIONS TO EXERCISES

1. Diatomic molecules: (a) HCl, (b) O₂, (h) ClF
2. Diatomic molecules: (d) HI, (f) Cl₂, (g) CO
3. (a) Potassium, iodine                      (d) Calcium, bromine
    (b) Sodium, carbon, oxygen               (e) Hydrogen, carbon, oxygen
    (c) Aluminum, oxygen
4. (a) Magnesium, bromine                  (d) Barium, sulfur, oxygen
    (b) Carbon, chlorine                      (e) Aluminum, phosphorus, oxygen
    (c) Hydrogen, nitrogen, oxygen
5. (a) ZnO                               (c) NaOH
    (b) KClO₃                             (d) C₂H₆O
6. (a) AlBr₃                              (c) PbCrO₄
    (b) CaF₂                           (d) C₆H₆
7. (a) C₆H₁₀OS₂                      (b) C₁₈H₂₇NO₃
    (c) C₁₀H₁₆
8. (a) C₅₅H₈₆NO₂₄                      (b) C₁₅H₁₄O₆
    (c) C₃₀H₄₈O₃
9. (a) 2 atoms iron, 3 atoms oxygen
    (b) 2 atoms calcium, 2 atoms nitrogen, 6 atoms oxygen
    (c) 1 atom cobalt, 4 atoms carbon, 6 atoms hydrogen, 4 atoms oxygen
    (d) 3 atoms carbon, 6 atoms hydrogen, 1 atom oxygen
    (e) 2 atoms potassium, 1 atom carbon, 3 atoms oxygen
    (f) 3 atoms copper, 2 atoms phosphorus, 8 atoms oxygen
    (g) 2 atoms carbon, 6 atoms hydrogen, 1 atom oxygen
    (h) 2 atoms sodium, 2 atoms chromium, 7 atoms oxygen
10. (a) 4 atoms hydrogen, 2 atoms carbon, 2 atoms oxygen
    (b) 3 atoms nitrogen, 12 atoms hydrogen, 1 atom phosphorus, 4 atoms oxygen
    (c) 1 atom magnesium, 2 atoms hydrogen, 2 atoms sulfur, 6 atoms oxygen
    (d) 1 atom zinc, 2 atoms chlorine
    (e) 1 atom nickel, 1 atom carbon, 3 atoms oxygen
    (f) 1 atom potassium, 1 atom manganese, 4 atoms oxygen
    (g) 4 atoms carbon, 10 atoms hydrogen
    (h) 1 atom lead, 1 atom chromium, 4 atoms oxygen
11. (a) 9 atoms              (b) 14 atoms     (c) 11 atoms     (d) 45 atoms
12. (a) 9 atoms              (b) 12 atoms     (c) 12 atoms     (d) 12 atoms

- 22 -
13. (a) 9 atoms H  
(b) 8 atoms H  
(c) 5 atoms H  
(d) 10 atoms H

14. (a) 6 atoms O  
(b) 4 atoms O  
(c) 6 atoms O  
(d) 21 atoms O

15. (a) mixture  
(b) mixture  
(c) pure substance  
(d) mixture  
(e) pure substance  
(f) mixture

16. (a) mixture  
(b) mixture  
(c) pure substance  
(d) pure substance  
(e) mixture  
(f) mixture

17. (c) compound  
(e) element

18. (c) element  
(d) compound

19. (a) mixture  
(b) compound

20. (a) compound  
(b) compound  
(c) mixture

21. Yes. The gaseous elements are all found on the extreme right of the periodic table. They are the entire last column and in the upper right corner of the table. Hydrogen is the exceptions and located at the upper left of the table.

22. No. The only common liquid elements (at room temperature) are mercury and bromine.

23. \[
\frac{18 \text{ metals}}{36 \text{ elements}} \times 100 = 50\% \text{ metals}
\]

24. \[
\frac{26 \text{ solids}}{36 \text{ elements}} \times 100 = 72\% \text{ solids}
\]

25. The formula for water is H₂O. There is one atom of oxygen for every two atoms of hydrogen. The molar mass of oxygen is 16.00 g and the molar mass of hydrogen is 1.008 g. For H₂O the mass of two hydrogen atoms is 2.016 g and the mass of one oxygen atom is 16.00 g. The ratio of hydrogen to oxygen is approximately 2:16 or 1:8. Therefore, there is 1 gram of hydrogen for every 8 grams of oxygen.

26. The formula for hydrogen peroxide is H₂O₂. There are two atoms of oxygen for every two atoms of hydrogen. The molar mass of oxygen is 16.00 g and the molar mass of hydrogen is 1.008 g. For hydrogen peroxide the total mass of hydrogen is 2.016 g and the total mass of oxygen is 32.00 g for a ratio of hydrogen to oxygen of approximately 2:32 or 1:16. Therefore, there is 1 gram of hydrogen for every 16 grams of oxygen.

27. To a small sample of the mixture, add water and observe that the salt dissolves but the pepper does not. After the small trial, add water to the entire mixture to dissolve the salt. Separate the undissolved pepper from the salt solution by filtering the mixture. Coffee filters or strong paper towels would work well for this process.
28. The atoms that make up each ionic compound are on opposite ends of the periodic table from one another. An ionic compound is made up of a metal-nonmetal combination.

29. (a) 1 carbon atom and 1 oxygen atom, total number of atoms = 2
(b) 1 boron atom and 3 fluorine atoms, total number of atoms = 4
(c) 1 hydrogen atom, 1 nitrogen atom, 3 oxygen atoms, total number of atoms = 5
(d) 1 potassium atom, 1 manganese atom, 4 oxygen atoms, total number of atoms = 6
(e) 1 calcium atom, 2 nitrogen atoms, 6 oxygen atoms, total number of atoms = 9
(f) 3 iron atoms, 2 phosphorus atoms, 8 oxygen atoms, total number of atoms = 13

30. (a) 181 atoms/module
   63 C
   88 N
   1 Co
   14 N
   14 O
   1 P
   \[\text{181 atoms}\]
(b) \[\frac{63 \text{ C}}{181 \text{ atoms}} \times 100 = 35\% \text{ C atoms}\]
(c) \[\frac{1 \text{ Co}}{181 \text{ atoms}} = \frac{1}{181} \text{ metals}\]

31. The conversion is: \(\text{cm}^3 \rightarrow \text{L} \rightarrow \text{mg} \rightarrow \text{g} \rightarrow \$

\[1 \times 10^{15} \text{ cm}^3 \left(\frac{1 \text{ L}}{1000 \text{ cm}^3}\right) \left(4 \times 10^{-4} \text{ mg}\right) \left(\frac{1 \text{ g}}{1000 \text{ mg}}\right) \left(\frac{\$19.40}{\text{ g}}\right) = 8 \times 10^6\]

32. \(\text{Ca(H}_2\text{PO}_4)_2\)
(10 formula units) \(\frac{4 \text{ atoms H}}{\text{formula unit}} = 40 \text{ atoms H}\)

33. \(\text{C}_{145}\text{H}_{293}\text{O}_{168}\)
145 C
293 H
168 O
\[\frac{606 \text{ atoms/molecule}}{}\]

34. (a) magnesium, manganese, molybdenum, mendeleevium, mercury, meitnerium
(b) carbon, phosphorus, sulfur, selenium, iodine, astatine, boron
(c) sodium, potassium, iron, silver, tin, antimony

35. Add water to the mixture to dissolve the sugar. Filter the mixture to separate the sugar solution from the insoluble sand. Add another small amount of water to remove last traces of sugar. Filter. Allow the water to evaporate from the sugar solution to obtain crystals of sugar. Sand is the insoluble residue.
36. HNO₃ has 5 atoms/molecule

7 dozen = 84

\[
\text{7 dozen } \times \text{ \(\frac{84 \text{ molecules}}{12 \text{ molecules/dz}}\) \times \text{ \(\frac{5 \text{ atoms}}{\text{molecule}}\)} = 420 \text{ atoms}
\]

or \(7 \text{ dz} \times \text{ \(\frac{12 \text{ molecules}}{\text{dz}}\)} \times \text{ \(\frac{5 \text{ atoms}}{\text{molecule}}\)} = 420 \text{ atoms}

37.

(a) As temperatures decreases, density increases.

(b) approximately 1.28 g/L at 5°C

approximately 1.18 g/L at 25°C

approximately 1.09 g/L at 70°C

38. Each represents eight units of sulfur. In 8 S the atoms are separate and distinct. In S₈ the atoms are joined as a unit (molecule).

39. (a) NaCl
(b) H₂SO₄
(c) K₂O
(d) Fe₂S₃
(e) K₃PO₄
(f) Ca(CN)₂
(g) C₆H₁₂O₆
(h) C₂H₅OH
(i) Cr(NO₃)₃

40. Let \(X\) = grams sea water

\[
\left( \frac{5.0 \times 10^{-8}}{100} \right) \times \text{I}_2 \text{ (X)} = 1.0 \text{ g I}_2
\]

\[
X = \frac{\text{(1.0 g I}_2\text{)(100)}}{\left(5.0 \times 10^{-8}\right) \text{ I}_2} = 2.0 \times 10^9 \text{ g sea water}
\]

\[
(2.0 \times 10^9 \text{ g}) \times \frac{1 \text{ kg}}{1000 \text{ g}} = 2.0 \times 10^6 \text{ kg sea water}
\]

41. (a) 12 carbons, 22 hydrogens, 11 oxygens

(b) 7 carbons, 5 hydrogens, 3 oxygens, 1 nitrogen, 1 sulfur

(c) 14 carbons, 18 hydrogens, 5 oxygens, 2 nitrogens

(d) 4 carbons, 4 hydrogens, 3 oxygens, 1 nitrogen, 1 sulfur, 1 potassium

(e) 12 carbons, 19 hydrogens, 8 oxygens, 3 chlorines
42. Cobalt should be written Co as CO is the formula for carbon monoxide.

43. \( \text{C}_4\text{N}_4\text{O}_2\text{H}_{10} \)

44. (a) \( \text{NH}_4\text{Cl} \)  
(b) \( \text{H}_2\text{SO}_4 \)  
(c) \( \text{MgI}_2 \)  
(d) \( \text{FeF}_2 \)  
(e) \( \text{Pb}_3(\text{PO}_4)_2 \)  
(f) \( \text{Al}_2\text{O}_3 \)

45. Group 1A oxides: \( \text{Li}_2\text{O}, \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{Rb}_2\text{O}, \text{Cs}_2\text{O} \)  
Group 2A oxides: \( \text{BeO}, \text{MgO}, \text{CaO}, \text{SrO}, \text{BaO} \)

46. (a) Arachidic acid 20 carbons, 40 hydrogens, and 2 oxygens  
Arachidonic acid 20 carbons, 32 hydrogens, and 2 oxygens  
(b) Stearic acid 18 carbons, 36 hydrogens, and 2 oxygens  
Linoleic acid 18 carbons, 32 hydrogens, and 2 oxygens  
(c) Arachidic acid \( \frac{40 \text{ H}}{20 \text{ C}} = \frac{2 \text{ H}}{\text{ C}} \)  
Arachidonic acid \( \frac{32 \text{ H}}{20 \text{ C}} = 1.6 \frac{\text{ H}}{\text{ C}} \)  
Stearic acid \( \frac{36 \text{ H}}{18 \text{ C}} = \frac{2 \text{ H}}{\text{ C}} \)  
Linoleic acid \( \frac{32 \text{ H}}{18 \text{ C}} = 1.8 \frac{\text{ H}}{\text{ C}} \)  
(d) Saturated molecules have more H’s per C than unsaturated molecules. Saturated molecules must have more hydrogen atoms.