Homework #1
Chapter 2
Atoms, Molecules, and Ions

19. \[ 1 \text{ L (Cl}_2 \text{)} + 5 \text{ L (F}_2 \text{)} \rightarrow 2 \text{ L (?)} \]
For gases the volume is proportional to the number of particiiples. Since it is proportional, we can simplify the problem by assuming that 1 particle = 1 L. Therefore, 1 Cl\textsubscript{2} molecule and 5 F\textsubscript{2} molecules must come together to make 2 molecules of a product. The 2 molecules of the product together must contain 2 Cl atoms and 10 F atoms. Therefore, each molecule contains 1 Cl atoms and 5 F atoms, giving ClF\textsubscript{5}.
Equation: Cl\textsubscript{2}(g) + 5F\textsubscript{2}(g) \rightarrow 2ClF\textsubscript{5}(g)

21. \[ 1 \text{ V (N}_2 \text{)} + 3 \text{ V (H}_2 \text{)} \rightarrow 2 \text{ V (?)} \]
For gases the volume is proportional to the number of particiiples. Since it is proportional, we can simplify the problem by assuming that 1 particle = 1 V. Therefore, 1 N\textsubscript{2} molecule and 3 H\textsubscript{2} molecules must come together to make 2 molecules of a product. The 2 molecules of the product together must contain 2 N atoms and 6 H atoms. Therefore, each molecule contains 1 N atoms and 3 H atoms, giving NH\textsubscript{3}.
Equation: N\textsubscript{2}(g) + 3H\textsubscript{2}(g) \rightarrow 2NH\textsubscript{3}(g)

28. Grapes are “1” in diameter, therefore, convert miles to inches
\[ 1 \text{ mi} \left( \frac{5280 \text{ ft}}{1 \text{ mi}} \right) \left( \frac{12 \text{ in}}{1 \text{ ft}} \right) = 63,360 \text{ in} \]

![Figure 2.13 from book](image)

The ratio of the nucleus size to electron cloud size is \( \frac{10^{-13} \text{ cm}}{10^{-8} \text{ cm}} = 1 \times 10^{-5} \) for an atom.
The ration for the nucleus size to electron cloud size is \( \frac{1 \text{ in}}{63,360 \text{ in}} = 2 \times 10^{-5} \) for the analogy.
Since the 2 ratio are similar the analogy is good.

32. a) Molecule: A neutrally charged group of atoms that are covalently bonded.
Ion: A charged species that can either contain a single atom or a group of atoms that are covalently bonded.
b) Covalent bond: Atoms that are held together by sharing electrons. Covalent bonds form between nonmetal atoms.
Ionic bond: Ions that are held together by the forces that attracts two oppositely charged species. Ionic bonds form between a metal cation and a non metal anion.
c) **Molecule**: A group of two or more non metal atoms held together by covalent bonds. The atoms in a molecule can be the same type example: H₂.

**Compound**: A substance containing two or more types of atoms that are either held together with covalent or ionic bonds.

d) **Anion**: An ion with a negative charge (due to an atom gaining electrons)

**Cation**: An ion with a positive charge (due to an atom losing electrons)

34. a) Mg metal  
    Ti metal  
    Au metal  
    Bi metal  
    Si nonmetal  
    Ge metal  
    B nonmetal  
    At nonmetal  
    Rn nonmetal  
    Eu metal  
    Am metal  
    Br nonmetal  

b) **metalloids**: B, Si, Ge, As, Sb, and Te (Po and At are sometimes recognized as metalloids)  

Therefore Si, Ge, B, and At, would be reclassified

36. Carbon is a nonmetal. Silicon and germanium are called metalloids as they exhibit both metallic and nonmetallic properties. Tin and lead are metals. Therefore, the metallic characteristics of elements increases as you go down groups in the periodic table. As you go across a period, from left to right the metallic characteristics of the elements decrease.

37. a) chlorine (Cl) halogen  
    b) beryllium (Be) alkaline earth metal  
    c) europium (Eu) lanthanide metal  
    d) hafnium (Hf) transition metal  
    e) helium (He) noble gas  
    f) uranium (U) actinide metal  
    g) caesium (Cs) alkali metal  

42. a) $^{58}_{27}Co$  
    b) $^{10}_{5}B$  
    c) $^{23}_{12}Mg$  
    d) $^{132}_{53}I$  
    e) $^{19}_{9}F$  
    f) $^{65}_{29}Cu$
43. | Symbol | # of p | # of n | # of e^- |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. $^{24}_{12}Mg$</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>B $^{23}_{12}Mg^{2+}$</td>
<td>12</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>C $^{59}_{27}Co^{2+}$</td>
<td>27</td>
<td>32</td>
<td>25</td>
</tr>
<tr>
<td>D $^{59}_{27}Co^{3+}$</td>
<td>27</td>
<td>32</td>
<td>24</td>
</tr>
<tr>
<td>E $^{59}_{27}Co$</td>
<td>27</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>F $^{79}_{34}Se$</td>
<td>34</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>G $^{79}_{34}Se^{2-}$</td>
<td>34</td>
<td>45</td>
<td>36</td>
</tr>
<tr>
<td>H $^{63}_{28}Ni$</td>
<td>28</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td>I $^{63}_{28}Ni^{2+}$</td>
<td>28</td>
<td>31</td>
<td>26</td>
</tr>
</tbody>
</table>

44. | Symbol | # of p | # of n | # of e^- | Net Charge |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{238}_{92}U$</td>
<td>92</td>
<td>146</td>
<td>92</td>
<td>0</td>
</tr>
<tr>
<td>$^{40}_{20}Ca^{2+}$</td>
<td>20</td>
<td>20</td>
<td>18</td>
<td>2+</td>
</tr>
<tr>
<td>$^{51}_{23}V^{3+}$</td>
<td>23</td>
<td>28</td>
<td>20</td>
<td>3+</td>
</tr>
<tr>
<td>$^{89}_{39}Y$</td>
<td>39</td>
<td>50</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>$^{79}_{35}Br^{−}$</td>
<td>35</td>
<td>44</td>
<td>36</td>
<td>1−</td>
</tr>
<tr>
<td>$^{31}_{15}P^{3−}$</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>3−</td>
</tr>
</tbody>
</table>

45. \( Z = p + n = 63 + 88 = 151 \)
\( A = p = 63 \)
\( ^{151}_{63}Eu^{3+} \)

\( Z = p + n = 50 + 68 = 118 \)
\( A = p = 50 \)
\( ^{118}_{50}Sn^{2+} \)

47. | Element | Gain/Lose | Ion |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ra</td>
<td>Lose</td>
<td>Ra^{2+}</td>
</tr>
<tr>
<td>b. In</td>
<td>Lose</td>
<td>In^{3+}</td>
</tr>
<tr>
<td>c. P</td>
<td>Gain</td>
<td>P^{3−}</td>
</tr>
<tr>
<td>d. Te</td>
<td>Gain</td>
<td>Te^{2−}</td>
</tr>
<tr>
<td>e. Br</td>
<td>Gain</td>
<td>Br^{−}</td>
</tr>
<tr>
<td>f. Rb</td>
<td>Lose</td>
<td>Rb^{+}</td>
</tr>
</tbody>
</table>

48. | Atomic # | Element | Ion |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 13</td>
<td>Al</td>
<td>Al^{3+}</td>
</tr>
<tr>
<td>b. 34</td>
<td>Se</td>
<td>Se^{2−}</td>
</tr>
<tr>
<td>c. 56</td>
<td>Ba</td>
<td>Ba^{2+}</td>
</tr>
<tr>
<td>d. 7</td>
<td>N</td>
<td>N^{3−}</td>
</tr>
<tr>
<td>e. 87</td>
<td>Fr</td>
<td>Fr^{+}</td>
</tr>
<tr>
<td>f. 35</td>
<td>Br</td>
<td>Br^{−}</td>
</tr>
</tbody>
</table>
53.  
   a) sulfur difluoride  
   b) dinitrogen tetroxide (drop the final vowel of the prefix if the element starts with a vowel)  
   c) iodine trichloride  
   d) tetraphosphorus hexoxide (drop the final vowel of the prefix if the element starts with a vowel)

54.  
   a) sodium perchlorate  
   b) magnesium phosphate  
   c) aluminum sulfate  
   d) sulfur difluoride  
   e) sulfur hexafluoride  
   f) sodium hydrogen phosphate  
   g) sodium dihydrogen phosphate  
   h) lithium nitride  
   i) sodium hydroxide  
   j) magnesium hydroxide  
   k) aluminum hydroxide  
   l) silver chromate*  
   * Even though silver is a transition metal it can only have one oxidation state, therefore, you do not include roman numerals.

55.  
   a) copper(I) iodide  
   b) copper(II) iodide  
   c) cobalt(II) iodide  
   d) sodium carbonate  
   e) sodium hydrogen carbonate  
   f) tetrasulfur tetranitride  
   g) selenium tetrabromide  
   h) sodium hypochlorite  
   i) barium chromate  
   j) ammonium nitrate  
   k) tin(IV) oxide*  
   *While tin can have oxidation states of 4+ and 2+ in this case the oxidation state would be 4+ therefore, the compound is not tin(II) perodixe but tin(IV) oxide. I will not give you anything this tricky on tests.

56.  
   a) acetic acid  
   b) ammonium nitrite  
   c) cobalt(III) sulfide  
   d) dinitrogen monoxide  
   e) lead(II) phosphate  
   f) potassium chlorate  
   g) sulfuric acid  
   h) strontium nitride  
   i) aluminum sulfite  
   j) tin(IV) oxide*  
   k) sodium chromate  
   l) hypochlorous acid  
   *While tin can have oxidation states of 4+ and 2+ in this case the oxidation state would be 4+ therefore, the compound is not tin(II) perodixe but tin(IV) oxide. I will not give you anything this tricky on tests.

57.  
   a) SO₂  
   b) SO₃  
   c) Na₂SO₃  
   d) KHSO₃  
   e) Li₃N  
   f) Cr₂(CO₃)₃  
   g) Cr₂(C₂H₃O₂)₃  
   h) SnF₄  
   i) NH₄HSO₄  
   j) (NH₄)₂HPO₄  
   k) KClO₄  
   l) NaH  
   m) HBrO  
   n) HBr

58.  
   a) Na₂O  
   b) Na₂O₂  
   c) KCN  
   d) Cu(NO₃)₂  
   e) SiCl₄  
   f) PbO  
   g) PbO₂  
   h) CuCl  
   i) GaAs  
   j) CdSe  
   k) ZnS  
   l) Hg₂Cl₂ (mercury(I) is a poly atomic ion Hg₂²⁺)  
   m) HNO₂  
   n) P₂O₅

59.  
   a) lead(III) acetate  
   b) copper(II) sulfate  
   c) calcium oxide  
   d) magnesium sulfate  
   e) magnesium hydroxide  
   f) calcium sulfate  
   g) dinitrogen monoxide
60. a) FeCl₃ iron chloride
   should be iron(III) chloride
   Iron forms more than one type of ion, therefore, roman numerals need to be used to denote which ion.

b) NO₂ nitrogen(IV) oxide
   should be nitrogen dioxide
   Both nitrogen and oxygen are nonmetals, therefore, the covalent naming system (Greek roots) should be used.

c) CaO calcium(II) monoxide
   should be calcium oxide
   Calcium only forms one ion, therefore, you do not need to include a roman numeral.
   CaO is an ionic compound (metal + nonmetal), therefore, you do not use Greek roots.

d) Al₂S₃ dialuminum trisulfide
   should be aluminum sulfide
   Al₂S₃ is an ionic compound (metal + nonmetal), therefore, you do not use Greek roots.

e) Mg(C₂H₃O₂)₂ manganese diacetate
   should be magnesium acetate
   Mg is magnesium not manganese (Mn).
   Mg is a metal and acetate is a polyatomic ion, therefore, the compound must be named like an ionic compound not a covalent compound.

f) FePO₄ iron(II) phosphide
   should be iron(III) phosphate
   PO₄³⁻ is phosphate and P₃⁻ is phosphide.
   The charge on phosphate is 3-, therefore, the charge on the Fe must be 3+.

g) P₂S₅ phosphorous sulfide
   should be diphosphorus pentasulfide
   Both phosphorous and sulfur are non metals, therefore, the covalent naming system (Greek roots) should be used.

h) Na₂O₂, sodium oxide
   should be sodium peroxide
   O₂²⁻ is a polyatomic ion, peroxide.

i) HNO₃, nitrate acid
   should be nitric acid
   If a polyatomic ion, in an acid, ends with –ate the root of the polyatomic ion is joined with –ic acid.

j) H₂S, sulfurous acid
   should be hydrosulfuric acid
   Anytime there is only H and 1 other type of atom hydro- is added to the beginning of the acids name and –ic is add to the root of the atom.

65. The equation that is being represented is 2Na(s) + Cl₂(g) → 2NaCl(s)
Picture 1 depicts sodium atoms that are in the solid phase.
Picture 2 depicts Cl₂ gas molecules. The Cl atoms are held together with covalent bond in the Cl₂ molecule.
Picture 3 depicts solid NaCl. NaCl is an ionic compound.
71. If X forms the compound XBr₂ the ion that forms must be X²⁺. Since the ion has 86 electrons the atom must have 88 protons making it radium, Ra.

\[ A = \#p + \# n \]
\[ \#n = A - \#p = 230 - 88 = 142 \]

78. a) Ca₃N₂ calcium nitride
b) K₂O potassium oxide
c) RbF rubidium fluoride
d) MgS magnesium sulfide
e) BaI₂ barium iodide
f) Al₂Se₃ aluminum selenide
g) Cs₃P cesium phosphide
h) InBr₃ indium bromide

90. a) The easy way to solve this problem is to assume that experiment one has a chemical formula of XY and experiment 2 has a chemical formula of YZ (Another equally valid assumption would be that experiment three has a formula of XY and experiment 2 has a formula of YZ.)

b) Below is that data that was given in the problem:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Amount of X (g)</th>
<th>Amount of Y (g)</th>
<th>Amount of Z (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td></td>
<td>7.0</td>
</tr>
</tbody>
</table>

To determine the relative weights of X, Y, and Z, scale experiment one to have 1 gram of Y. Y was set to 1 because all of the compounds have Y in them.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Amount of X (g)</th>
<th>Amount of Y (g)</th>
<th>Amount of Z (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 scaled</td>
<td>0.4</td>
<td>0.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Therefore, for every 1 gram of Y there are 0.095 grams of X. To determine the relative weight of Z, scale experiment 2 to have 1.0 g of Y.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Amount of X (g)</th>
<th>Amount of Y (g)</th>
<th>Amount of Z (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 scaled</td>
<td></td>
<td>1.4</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Therefore, for every 1 gram of Y there is 0.095 g of X and 0.71 g of Z. Or the mass of X is 0.095 times that of Y and the mass of Z is 0.71 times that of Y.

X:Y:Z = 0.095 g:1.0g:0.71 g (there are multiple correct answers for this part but if you made the same assumptions (compound 1 XY and compound 2 YZ) then your answer should be proportional to this answer.

c) In part a we assumed that the formula of experiment 1 was XY and experiment 2 is YZ. To get the formula of experiment 3 apply to law of multiple proportions. In order to do this experiment three needs to be scaled to have 1.0 grams of Y.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Amount of X (g)</th>
<th>Amount of Y (g)</th>
<th>Amount of Z (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.095</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>3 scaled</td>
<td>2.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
</tbody>
</table>

2.9 is 3 times larger than 0.095 therefore the chemical formula for experiment 3 would be \( X_3Y \).
d) The mass % of each of the types of atoms is constant regardless of sample size. Therefore, since experiment one (X=0.095 g and Y=1.0 g) was assumed to have the formula XY the mass percent can be determined from this experiment.

\[
\text{mass } \% \text{ } X = \frac{m_X}{m_{tot}} \times 100% = \frac{0.095 \text{ } g}{0.095 \text{ } g + 1.0 \text{ } g} \times 100% = 8.7%
\]

\[
\text{mass } \% \text{ } Y = \frac{m_Y}{m_{tot}} \times 100% = \frac{1.0 \text{ } g}{0.095 \text{ } g + 1.0 \text{ } g} \times 100% = 91.3%
\]

Determine the mass of X in the 21 g sample

\[m_X = (21\text{ }g)(0.087) = 1.8 \text{ } g\]

Determine the mass of Y in the 21 g sample

\[m_Y = (21\text{ }g)(0.913) = 19.2 \text{ } g\]

Note: If you had assumed that experiment three was XY then you should have found that there is 6.0 g of X and 15.0 g of Y.

91. The following data was collected:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Amount of R (g)</th>
<th>Amount of Q (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

In order to compare experiment 1 and 2 you need to scale experiment 2 such that 14.0 grams of R was used. This would give the following:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Amount of R (g)</th>
<th>Amount of Q (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(scaled)</td>
<td>7.0x2=14.0</td>
<td>4.5x2=9.0</td>
</tr>
</tbody>
</table>

To see if this is consistent with the law of multiple proportions you need to compare the ratio of the two amounts of Q. If these come out to a whole number then it is consistent.

\[
\frac{\text{larger number}}{\text{smaller number}} = \frac{9.0}{3.0} = 3.0
\]

Therefore, this is consistent with the law of multiple proportions.

If experiment 2 had the formula RQ then experiment one would have the formula \(RQ_{1/3}\). Chemical formulas do not have fractions in them, to get rid of the fraction assume there are 3 R atoms. This results in the chemical formula \(R_3Q\).
For gases the volume is proportional to the number of particles. Since it is proportional, we can simplify the problem by assuming that 1 particle = 1 V.

For reaction 1:
\[ 1 \text{ V} (X_2) + 2 \text{ V} (Y) \rightarrow 2 \text{ V} (X_2Y) \]
The only way to form 2 particles of product (compound 1) is to have X be a diatomic (X₂)

For reaction 2:
\[ 2 \text{ V} (X_2) + 1 \text{ V} (Y) \rightarrow 2 \text{ V} (X_2Y) \]
The only way to form 2 particles of product (compound 2) is to have Y be a diatomic (Y₂)
This suggests that compound 1 is \( XY_2 \) and compound 2 is \( X_2Y \).

The mass percent data can be used to check the formulas.

Compound 1 (\( XY_2 \)) is 30.45% X and 69.57% Y. If you have 100 g then 30.45 g are X and 69.57 g are Y. Therefore, the relative mass ratio of X:Y is 30.45:34.79.

If this is the case then compound 2 (\( X_2Y \)) would have the following mass percents:

\[
\begin{align*}
\text{mass} \% \text{ x} &= \frac{2(30.45)}{2(30.45)+34.79} \times 100\% = 63.64\% \\
\text{mass} \% \text{ y} &= \frac{34.79}{2(30.45)+34.79} \times 100\% = 36.36\%
\end{align*}
\]

This is consistent with the experimentally found data therefore:

Compound 1: \( XY_2 \) and Compound 2: \( X_2Y \)