

### Solutions to the Extra Problems for Chapter 6

1. The temperature is 23.9 °C. We can convert between Fahrenheit and Celsius with Equation (6.1):

$$^{\circ}\text{F} = \frac{9}{5}(^{\circ}\text{C}) + 32$$

Putting in the Fahrenheit temperature:

$$75.0 = \frac{9}{5}(^{\circ}\text{C}) + 32$$

Now we have to use algebra to solve the equation. First, we subtract 32 from both sides:

$$75.0 - 32 = \frac{9}{5}(^{\circ}\text{C})$$

Then we multiply both sides by 5/9:

$$\frac{5}{9}(75.0 - 32) = ^{\circ}\text{C}$$

Since addition and subtraction go by different rules from multiplication and division, we will have to take care of significant figures twice: once after we subtract and then again after we multiply. The 32 is exact, so the precision of 75.0 determines the precision of the answer. It must be reported to the tenths place:

$$\frac{5}{9}(43.0) = ^{\circ}\text{C}$$

The 5 and 9 are exact, so the only important number from a significant figures standpoint is 43.0, which has three. Thus, our answer must have three: 23.9 °C.

2. The temperature is 2,590 °F. This requires Equation (6.1):

$$^{\circ}\text{F} = \frac{9}{5}(^{\circ}\text{C}) + 32 = \frac{9}{5}(1,420) + 32$$

Since addition and subtraction go by different rules from multiplication and division, we will have to take care of significant figures twice: once after we multiply and again after we add. The 9 and 5 are exact, so 1,420 is the key for significant figures. It has three, so the answer must have three:

$$^{\circ}\text{F} = 2,560 + 32$$

Now we are adding, so we go by precision. The 32 is exact, so the only thing that matters is the 2,560. It has its last significant figure in the tens place, so the answer must go to the tens place: 2,590 °F.

3. The lower the temperature, the slower the molecular motion. However, to compare the temperatures, they need to be in the same unit. You can convert either to compare, but Equation (6.1) makes it easier to convert to °F, so that's what I will do:

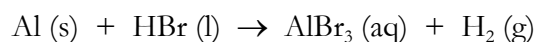
$$^{\circ}\text{F} = \frac{9}{5}(^{\circ}\text{C}) + 32 = \frac{9}{5}(700.0) + 32 = 1,292 \text{ }^{\circ}\text{F}$$

That's hotter than 1,115 °F, so the sample at 1,115 °F has molecules that are moving more slowly.

4. In a heating curve, the flat parts represent phase changes. The lower-temperature phase change will be melting, while the higher-temperature one will be boiling. Therefore:

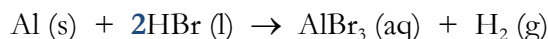
- It melts at 40 °C, because the first flat portion of the heating curve is at 40 °C.
- It boils at 160 °C, because the second flat portion of the heating curve is at 160 °C.
- At 20 °C, the graph is before the first phase change (melting). That means it has not melted yet, so it is solid.

5. a. The balanced equation is 2Al (s) + 6HBr (l) → 2AlBr<sub>3</sub> (aq) + 3H<sub>2</sub> (g). Hydrogen monobromide has one H and one Br, so it is HBr. For aluminum bromide, Al is in Group 3A, so it becomes 3+ in ionic compounds. Br is in Group 7A, so it becomes 1-. That means aluminum bromide is AlBr<sub>3</sub>. Hydrogen as an element is a homonuclear diatomic, so it is H<sub>2</sub>. The unbalanced equation, then, is:



Atomic Symbol	Number on the reactants side	Number on the products side
Al	1×1 = 1	1×1 = 1
H	1×1 = 1	1×2 = 2
Br	1×1 = 1	1×3 = 3

The Al atoms are balanced, but the H atoms are not. We can fix that:



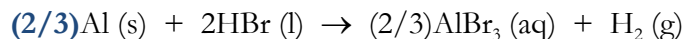
Atomic Symbol	Number on the reactants side	Number on the products side
Al	1×1 = 1	1×1 = 1
H	<b>2</b> ×1 = 2	1×2 = 2
Br	<b>2</b> ×1 = 2	1×3 = 3

The easiest way to balance the Br's now is to multiply AlBr<sub>3</sub> by 2/3:



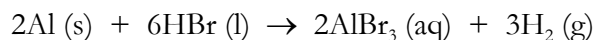
Atomic Symbol	Number on the reactants side	Number on the products side
Al	1×1 = 1	<b>(2/3)</b> ×1 = 2/3
H	2×1 = 2	1×2 = 2
Br	2×1 = 2	<b>(2/3)</b> ×3 = 2

But now we have to multiply Al by 2/3:

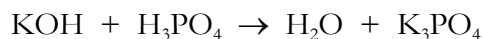


Atomic Symbol	Number on the reactants side	Number on the products side
Al	$(2/3) \times 1 = 2/3$	$(2/3) \times 1 = 2/3$
H	$2 \times 1 = 2$	$1 \times 2 = 2$
Br	$2 \times 1 = 2$	$(2/3) \times 3 = 2$

Now everything is balanced, but we have to multiply by 3 to get rid of the fractions:

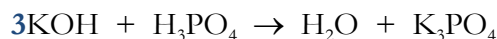


b. The balanced equation is  $3\text{KOH} + \text{H}_3\text{PO}_4 \rightarrow 3\text{H}_2\text{O} + \text{K}_3\text{PO}_4$ . We already have the unbalanced equation:



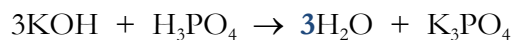
Atomic Symbol	Number on the reactants side	Number on the products side
K	$1 \times 1 = 1$	$1 \times 3 = 3$
O	$1 \times 1 + 1 \times 4 = 5$	$1 \times 1 + 1 \times 4 = 5$
H	$1 \times 1 + 1 \times 3 = 4$	$1 \times 2 = 2$
P	$1 \times 1 = 1$	$1 \times 1 = 1$

We need to balance the K's:



Atomic Symbol	Number on the reactants side	Number on the products side
K	$3 \times 1 = 3$	$1 \times 3 = 3$
O	$3 \times 1 + 1 \times 4 = 7$	$1 \times 1 + 1 \times 4 = 5$
H	$3 \times 1 + 1 \times 3 = 6$	$1 \times 2 = 2$
P	$1 \times 1 = 1$	$1 \times 1 = 1$

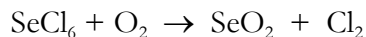
Normally, we would skip the O's and H's, since they appear multiple times. However, the P's are balanced, so we have to deal with either O or H. We will do H, since it appears fewer times:



Atomic Symbol	Number on the reactants side	Number on the products side
K	$3 \times 1 = 3$	$1 \times 3 = 3$
O	$3 \times 1 + 1 \times 4 = 7$	$3 \times 1 + 1 \times 4 = 7$
H	$3 \times 1 + 1 \times 3 = 6$	$3 \times 2 = 6$
P	$1 \times 1 = 1$	$1 \times 1 = 1$

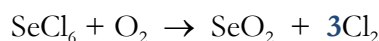
Now everything is balanced.

c. The balanced equation is  $\text{SeCl}_6 + \text{O}_2 \rightarrow \text{SeO}_2 + 3\text{Cl}_2$ .



Atomic Symbol	Number on the reactants side	Number on the products side
Se	$1 \times 1 = 1$	$1 \times 1 = 1$
Cl	$1 \times 6 = 6$	$1 \times 2 = 2$
O	$1 \times 2 = 2$	$1 \times 2 = 2$

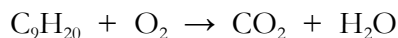
The only thing we need to do is balance the Cl's:



Atomic Symbol	Number on the reactants side	Number on the products side
Se	$1 \times 1 = 1$	$1 \times 1 = 1$
Cl	$1 \times 6 = 6$	$3 \times 2 = 6$
O	$1 \times 2 = 2$	$1 \times 2 = 2$

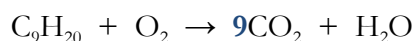
Now everything is balanced.

d. The balanced equation is  $\text{C}_9\text{H}_{20} + 14\text{O}_2 \rightarrow 9\text{CO}_2 + 10\text{H}_2\text{O}$ .



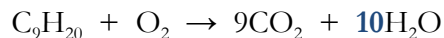
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 9 = 9$	$1 \times 1 = 1$
H	$1 \times 20 = 20$	$1 \times 2 = 2$
O	$1 \times 2 = 2$	$1 \times 2 + 1 \times 1 = 3$

Starting with the C's:



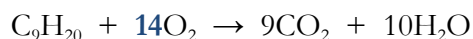
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 9 = 9$	$9 \times 1 = 9$
H	$1 \times 20 = 20$	$1 \times 2 = 2$
O	$1 \times 2 = 2$	$9 \times 2 + 1 \times 1 = 19$

Moving on to the H's:



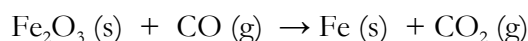
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 9 = 9$	$9 \times 1 = 9$
H	$1 \times 20 = 20$	$10 \times 2 = 20$
O	$1 \times 2 = 2$	$9 \times 2 + 10 \times 1 = 28$

Now the O's:



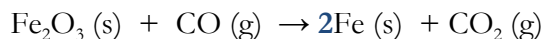
Atomic Symbol	Number on the reactants side	Number on the products side
C	1×9 = 9	9×1 = 9
H	1×20 = 20	10×2 = 20
O	14×2 = 28	9×2 + 10×1 = 28

e. The balanced equation is  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{s}) + 3\text{CO}_2(\text{g})$ . Iron (III) oxide means iron is in the 3+ state. Oxygen is in Group 6A, so it takes on a 2- charge in ionic compounds, making iron (III) oxide  $\text{Fe}_2\text{O}_3$ . Carbon monoxide is CO, and carbon dioxide is  $\text{CO}_2$ . That means the unbalanced equation is:



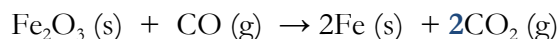
Atomic Symbol	Number on the reactants side	Number on the products side
Fe	1×2 = 2	1×1 = 1
O	1×3 + 1×1 = 4	1×2 = 2
C	1×1 = 1	1×1 = 1

Balancing the Fe's is easy:



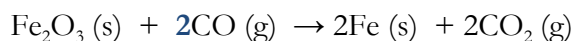
Atomic Symbol	Number on the reactants side	Number on the products side
Fe	1×2 = 2	2×1 = 2
O	1×3 + 1×1 = 4	1×2 = 2
C	1×1 = 1	1×1 = 1

Now it becomes difficult. The C's are balanced, but the O's are not. You might try balancing the O's this way:



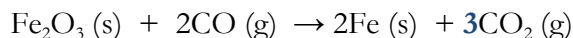
Atomic Symbol	Number on the reactants side	Number on the products side
Fe	1×2 = 2	2×1 = 2
O	1×3 + 1×1 = 4	2×2 = 4
C	1×1 = 1	2×1 = 2

Now the O's are balanced, but the C's aren't. I don't want to mess with the Fe's, because they have been balanced already. So let's just try playing with the C's and O's. I need more C's on the reactants side, so let's just multiply CO by 2:



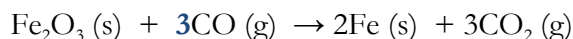
Atomic Symbol	Number on the reactants side	Number on the products side
Fe	1×2 = 2	2×1 = 2
O	1×3 + 2×1 = 5	2×2 = 4
C	2×1 = 2	2×1 = 2

The C's are balanced again, but now I need more O's on the products side. Let's make more O's:



Atomic Symbol	Number on the reactants side	Number on the products side
Fe	$1 \times 2 = 2$	$2 \times 1 = 2$
O	$1 \times 3 + 1 \times 2 = 5$	$3 \times 2 = 6$
C	$1 \times 2 = 2$	$3 \times 1 = 3$

What good did that do? Look what happens when I now make more C's and O's on the reactants side:



Atomic Symbol	Number on the reactants side	Number on the products side
Fe	$1 \times 2 = 2$	$2 \times 1 = 2$
O	$1 \times 3 + 3 \times 1 = 6$	$2 \times 3 = 6$
C	$3 \times 1 = 3$	$3 \times 1 = 3$

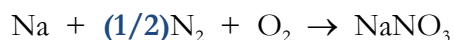
Now everything is balanced. Sometimes, this kind of trial and error is the only way to balance these reactions.

6. a. The balanced equation is  $2\text{Na} + \text{N}_2 + 3\text{O}_2 \rightarrow 2\text{NaNO}_3$ . A formation reaction forms the compound from its elements.  $\text{NaNO}_3$  has the elements sodium, nitrogen, and oxygen. Remember, however, that oxygen and nitrogen are homonuclear diatomics:



Atomic Symbol	Number on the reactants side	Number on the products side
Na	$1 \times 1 = 1$	$1 \times 1 = 1$
N	$1 \times 2 = 2$	$1 \times 1 = 1$
O	$1 \times 2 = 2$	$1 \times 3 = 3$

The easiest way to balance the N's without upsetting the Na's is to multiply  $\text{N}_2$  by 1/2:



Atomic Symbol	Number on the reactants side	Number on the products side
Na	$1 \times 1 = 1$	$1 \times 1 = 1$
N	$(1/2) \times 2 = 1$	$1 \times 1 = 1$
O	$1 \times 2 = 2$	$1 \times 3 = 3$

The easiest way to balance the O's is to multiply  $\text{O}_2$  by 3/2:



Atomic Symbol	Number on the reactants side	Number on the products side
Na	$1 \times 1 = 1$	$1 \times 1 = 1$
N	$(1/2) \times 2 = 1$	$1 \times 1 = 1$
O	$(3/2) \times 2 = 3$	$1 \times 3 = 3$

Now we just multiply by 2 to get rid of the fractions:



b. The balanced equation is  $2\text{C}_3\text{H}_8\text{O} \rightarrow 6\text{C} + 8\text{H}_2 + \text{O}_2$ . Decomposition means starting with the compound ( $\text{C}_3\text{H}_8\text{O}$ ) and producing its elements – carbon, hydrogen, and oxygen. We have to remember that hydrogen and oxygen are homonuclear diatomics.



Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$1 \times 1 = 1$
H	$1 \times 8 = 8$	$1 \times 2 = 2$
O	$1 \times 1 = 1$	$1 \times 2 = 2$

Balancing the C's:



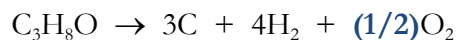
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$1 \times 2 = 2$
O	$1 \times 1 = 1$	$1 \times 2 = 2$

Balancing the H's:



Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$4 \times 2 = 8$
O	$1 \times 1 = 1$	$1 \times 2 = 2$

Balancing the O's:

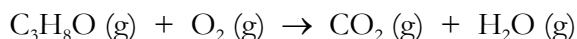


Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$4 \times 2 = 8$
O	$1 \times 1 = 1$	$(1/2) \times 2 = 1$

Now just multiply by 2 to get rid of the fraction:

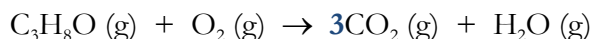


c. The balanced equation is  $2\text{C}_3\text{H}_8\text{O}(\text{g}) + 9\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 8\text{H}_2\text{O}(\text{g})$ . Complete combustion means reacting the fuel ( $\text{C}_3\text{H}_8\text{O}$ ) with oxygen (a homonuclear diatomic) to get carbon dioxide and water. Remember that the carbon dioxide and water are gases, as is oxygen. The problem tells us that the fuel is a gas, so the unbalanced equation is:



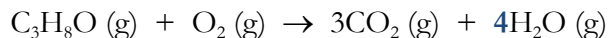
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$1 \times 1 = 1$
H	$1 \times 8 = 8$	$1 \times 2 = 2$
O	$1 \times 1 + 1 \times 2 = 3$	$1 \times 2 + 1 \times 1 = 3$

To balance the C atoms, we must multiply  $\text{CO}_2$  by 3:



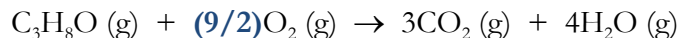
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$1 \times 2 = 2$
O	$1 \times 1 + 1 \times 2 = 3$	$3 \times 2 + 1 \times 1 = 7$

Now we balance the H's:



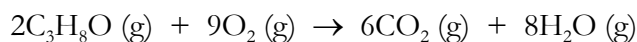
Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$4 \times 2 = 8$
O	$1 \times 1 + 1 \times 2 = 3$	$3 \times 2 + 4 \times 1 = 10$

To balance the O's, we don't want to mess with  $\text{C}_3\text{H}_8\text{O}$ , since that will throw off the C's and H's. To get 10 O's on the reactants side, then, we need 9 of them to come from  $\text{O}_2$ :



Atomic Symbol	Number on the reactants side	Number on the products side
C	$1 \times 3 = 3$	$3 \times 1 = 3$
H	$1 \times 8 = 8$	$4 \times 2 = 8$
O	$1 \times 1 + (9/2) \times 2 = 10$	$3 \times 2 + 4 \times 1 = 10$

Now we just multiply by 2 to get rid of the fraction:





7. a. The Cl's move from the Cu to the Mg, so it is a single displacement reaction.
- b. This takes elements and makes a compound, so it is a formation reaction.
- c. The Ag and Na change places, so this is a double displacement reaction.
- d. This takes a compound and adds oxygen to it, so it is a kind of combustion reaction. However, CO<sub>2</sub> is not made. Instead, it is CO. That makes this an incomplete combustion reaction.
- e. This starts with a single compound and makes elements, so it is a decomposition reaction.