Solutions to the Extra Problems for Chapter 7

1. a. The answer is 3.560 moles. The Periodic Table says that Si has a mass of 28.09 amu. That also tells us:

$$1 \text{ mole Si} = 28.09 \text{ g Si}$$

We can use that to convert between grams and moles:

$$\frac{100.0 \cancel{\text{g Si}}}{1} \times \frac{1 \text{ mole Si}}{28.09 \cancel{\text{g Si}}} = 3.560 \text{ moles Si}$$

Since we can have only four significant figures in the answer, we have to round 3.55998… Dropping the second "9" means rounding "59" to "60." We have to keep the zero, however, to have four significant figures.

b. The answer is 8.324 moles. The Periodic Table says that H_2O has a mass of:

$$\text{Mass of } H_2O = 2\times1.01 \text{ amu} + 16.00 \text{ amu} = 18.02 \text{ amu}$$

Remember, this is like addition, since the number of atoms in a molecule is exact. Thus, we use the rules of addition for significant figures, which means we report our answer to the same decimal place as the least precise number in the problem. Since both the numbers have their last significant digit in the hundredths place, our answer must as well. That means:

$$1 \text{ mole } H_2O = 18.02 \text{ g } H_2O$$

We can use that to convert between grams and moles:

$$\frac{150.0 \cancel{\text{g } H_2O}}{1} \times \frac{1 \text{ mole } H_2O}{18.02 \cancel{\text{g } H_2O}} = 8.324 \text{ moles } H_2O$$

c. The answer is 2.775 moles. The Periodic Table says that $C_6H_{12}O_6$ has a mass of:

$$\text{Mass of } C_6H_{12}O_6 = 6\times12.01 \text{ amu} + 12\times1.01 \text{ amu} + 6\times16.00 \text{ amu} = 180.18 \text{ amu}$$

Remember, we use the rules of addition to determine the significant figures. All the numbers have their last significant figure in the hundredths place, so the answer must as well. That means:

$$1 \text{ mole } C_6H_{12}O_6 = 180.18 \text{ g } C_6H_{12}O_6$$

We can use that to convert between grams and moles:

$$\frac{500.0 \cancel{\text{g } C_6H_{12}O_6}}{1} \times \frac{1 \text{ mole } C_6H_{12}O_6}{180.18 \cancel{\text{g } C_6H_{12}O_6}} = 2.775 \text{ moles } C_6H_{12}O_6$$

2. a. The answer is 173 g. The Periodic Table says that S has a mass of 32.06 amu. That also tells us:

$$1 \text{ mole S} = 32.06 \text{ g S}$$

We can use that to convert between moles and grams:

$$\frac{5.41 \cancel{\text{moles S}}}{1} \times \frac{32.06 \text{ g S}}{1 \cancel{\text{mole S}}} = 173 \text{ g S}$$

b. The answer is 8.9 g. The Periodic Table says that KCl has a mass of:

$$\text{Mass of KCl} = 39.10 \text{ amu} + 35.45 \text{ amu} = 74.55 \text{ amu}$$

That means:

$$1 \text{ mole KCl} = 74.55 \text{ g KCl}$$

We can use that to convert between moles and grams:

$$\frac{0.12 \cancel{\text{moles KCl}}}{1} \times \frac{74.55 \text{ g KCl}}{1 \cancel{\text{mole KCl}}} = 8.9 \text{ g KCl}$$

c. The answer is 81.15 g. The Periodic Table says that C_2H_6O has a mass of:

$$\text{Mass of } C_2H_6O = 2 \times 12.01 \text{ amu} + 6 \times 1.01 \text{ amu} + 16.00 \text{ amu} = 46.08 \text{ amu}$$

That means

$$1 \text{ mole } C_2H_6O = 46.08 \text{ g } C_2H_6O$$

We can use that to convert between moles and grams:

$$\frac{1.761 \cancel{\text{moles } C_2H_6O}}{1} \times \frac{46.08 \text{ g } C_2H_6O}{1 \cancel{\text{mole } C_2H_6O}} = 81.15 \text{ g } C_2H_6O$$

3. The answer is 1.24×10^{25} atoms. We don't know any relationship between grams and atoms, but we do know a relationship between grams and moles. The Periodic Table says that magnesium (Mg) has a mass of 24.31 amu. That also tells us:

$$1 \text{ mole Mg} = 24.31 \text{ g Mg}$$

We can use that to convert between grams and moles:

$$\frac{500.0 \cancel{\text{g Mg}}}{1} \times \frac{1 \text{ mole Mg}}{24.31 \cancel{\text{g Mg}}} = 20.57 \text{ moles Mg}$$

Since we know that a mole is 6.02×10^{23}, we can say:

$$1 \text{ mole Mg} = 6.02\times10^{23} \text{ atoms Mg}$$

This allows us to convert to the number of atoms:

$$\frac{20.57 \cancel{\text{moles Mg}}}{1}\times\frac{6.02\times10^{23}\text{ atoms Mg}}{1 \cancel{\text{mole Mg}}} = 1.24\times10^{25}\text{ atoms Mg}$$

4. The answer is 4.52×10^{22} molecules. We don't know any relationship between grams and molecules, but we do know a relationship between grams and moles. Since moles are a way of counting molecules, we should start there. The Periodic Table says that $AlCl_3$ has a mass of:

$$\text{Mass of } AlCl_3 = 26.98 \text{ amu} + 3\times35.45 \text{ amu} = 133.33 \text{ amu}$$

Remember, we use the rules of addition to determine the significant figures. All the numbers have their last significant figure in the hundredths place, so the answer must as well. This tells us:

$$1 \text{ mole } AlCl_3 = 133.33 \text{ g } AlCl_3$$

We can use that to convert between grams and moles:

$$\frac{10.0 \cancel{\text{g AlCl}_3}}{1}\times\frac{1 \text{ mole AlCl}_3}{133.33 \cancel{\text{g AlCl}_3}} = 0.0750 \text{ moles AlCl}_3$$

Since we know that a mole is 6.02×10^{23}, we can say:

$$1 \text{ mole } AlCl_3 = 6.02\times10^{23} \text{ molecules } AlCl_3$$

This allows us to convert to the number of molecules:

$$\frac{0.0750 \cancel{\text{moles AlCl}_3}}{1}\times\frac{6.02\times10^{23}\text{ molecules AlCl}_3}{1 \cancel{\text{mole AlCl}_3}} = 4.52\times10^{22}\text{ molecules AlCl}_3$$

5. The answers are 83 moles and 1,400 g. Since we know that a mole is 6.02×10^{23}, we can say:

$$1 \text{ mole } NH_3 = 6.02\times10^{23} \text{ molecules } NH_3$$

That allows us to convert between molecules and moles:

$$\frac{5.0\times10^{25} \cancel{\text{molecules NH}_3}}{1}\times\frac{1 \text{ mole NH}_3}{6.02\times10^{23} \cancel{\text{molecules NH}_3}} = 83 \text{ moles NH}_3$$

Now that we know moles, we can convert to grams, once we have the mass:

$$\text{Mass of } NH_3 = 14.01 \text{ amu} + 3 \times 1.01 \text{ amu} = 17.04 \text{ amu}$$

This tells us:

$$1 \text{ mole } NH_3 = 17.04 \text{ g } NH_3$$

We can use that to convert between moles and grams:

$$\frac{83 \cancel{\text{moles } NH_3}}{1} \times \frac{17.04 \text{ g } NH_3}{1 \cancel{\text{mole } NH_3}} = 1{,}400 \text{ g } NH_3$$

6. a. For the hydrated form, we write the chemical formula, a dot, and then the number of H_2O molecules per molecule of the anhydrous form. That means <u>the hydrated form is $Na_2CO_3 \cdot 10H_2O$.</u>

b. The answer is <u>85.1 g</u>. Remember, each Na_2CO_3 can have ten water molecules. So, we need to know how many Na_2CO_3 molecules we have. To count molecules, we must convert from grams to moles:

$$\text{Mass of } Na_2CO_3 = 2 \times 22.99 \text{ amu} + 12.01 \text{ amu} + 3 \times 16.00 \text{ amu} = 105.99 \text{ amu}$$

That means

$$1 \text{ mole } Na_2CO_3 = 105.99 \text{ g } Na_2CO_3$$

We can use that to convert between grams and moles:

$$\frac{50.0 \cancel{\text{ g } Na_2CO_3}}{1} \times \frac{1 \text{ mole } Na_2CO_3}{105.99 \cancel{\text{ g } Na_2CO_3}} = 0.472 \text{ moles } Na_2CO_3$$

We know that each Na_2CO_3 can have ten water molecules, so the moles of water molecules are ten times that:

$$\text{Moles of water} = 10 \times \text{moles of } Na_2CO_3 = 10 \times 0.472 \text{ moles} = 4.72 \text{ moles}$$

Remember, you can't have a fraction of a molecule, so the "10" is exact. That means the only thing that matters in terms of significant figures is the 0.472, which has three, so our answer must have three. That's the number of moles of water that can be absorbed, but the question asked for grams, so we have to convert:

$$\text{Mass of } H_2O = 2 \times 1.01 \text{ amu} + 16.00 \text{ amu} = 18.02 \text{ amu}$$

This tells us

$$1 \text{ mole } H_2O = 18.02 \text{ g } H_2O$$

We can use that to convert between moles and grams:

$$\frac{4.72 \cancel{\text{ moles } H_2O}}{1} \times \frac{18.02 \text{ g } H_2O}{1 \cancel{\text{ mole } H_2O}} = 85.1 \text{ g } H_2O$$

7. a. You need <u>20.0 moles</u>. The chemical reaction gives us the relationship between the reactants and products in terms of moles:

$$1 \text{ mole } Na_2SO_4 \ = \ 2 \text{ moles Na}$$

We can use that to convert between moles of Na_2SO_4 and moles of Na:

$$\frac{10.0 \ \cancel{\text{moles } Na_2SO_4}}{1} \times \frac{2 \text{ moles Na}}{1 \ \cancel{\text{mole } Na_2SO_4}} = 20.0 \text{ moles Na}$$

b. You need <u>10.0 moles</u>. The chemical reaction gives us the relationship between the reactants and products in terms of moles:

$$1 \text{ mole } Na_2SO_4 \ = \ 1 \text{ mole S}$$

We can use that to convert between moles of Na_2SO_4 and moles of S:

$$\frac{10.0 \ \cancel{\text{moles } Na_2SO_4}}{1} \times \frac{1 \text{ mole S}}{1 \ \cancel{\text{mole } Na_2SO_4}} = 10.0 \text{ moles S}$$

c. You need <u>20.0 moles</u>. The chemical reaction gives us the relationship between the reactants and products in terms of moles:

$$1 \text{ mole } Na_2SO_4 \ = \ 2 \text{ moles } O_2$$

We can use that to convert between moles of Na_2SO_4 and moles of O_2:

$$\frac{10.0 \ \cancel{\text{moles } Na_2SO_4}}{1} \times \frac{2 \text{ moles } O_2}{1 \ \cancel{\text{mole } Na_2SO_4}} = 20.0 \text{ moles } O_2$$

8. <u>The answer is 7.5 moles</u>. In this reaction, we know that HCl is the limiting reactant, because the other reactant is in excess. Thus, HCl determines the amount of products. The chemical equation tells us:

$$2 \text{ moles HCl} \ = \ 1 \text{ mole } H_2$$

We can use this to convert between moles of HCl and moles of H_2:

$$\frac{15 \ \cancel{\text{moles HCl}}}{1} \times \frac{1 \text{ mole } H_2}{2 \ \cancel{\text{moles HCl}}} = 7.5 \text{ moles } H_2$$

9. <u>The answer is 3,266 g</u>. In this reaction, we know that we want to make 100.0 moles of water. The equation gives us a relationship between moles of water and moles of H_3PO_4:

$$3 \text{ moles } H_2O \ = \ 1 \text{ mole } H_3PO_4$$

We can use this to convert between moles of water and moles of H_3PO_4:

$$\frac{100.0 \; \cancel{\text{moles } H_2O}}{1} \times \frac{1 \text{ moles } H_3PO_4}{3 \; \cancel{\text{moles } H_2O}} = 33.33 \text{ moles } H_3PO_4$$

Unfortunately, we aren't done, because the mean author wants the answer in grams. Since we know the number of moles, we just have to convert to grams:

$$\text{Mass of } H_3PO_4 = 3 \times 1.01 \text{ amu} + 30.97 \text{ amu} + 4 \times 16.00 \text{ amu} = 98.00 \text{ amu}$$

This tells us:

$$1 \text{ mole } H_3PO_4 = 98.00 \text{ g } H_3PO_4$$

We can use that to convert between moles and grams:

$$\frac{33.33 \; \cancel{\text{moles } H_3PO_4}}{1} \times \frac{98.00 \text{ g } H_3PO_4}{1 \; \cancel{\text{mole } H_3PO_4}} = 3{,}266 \text{ g } H_3PO_4$$

10. <u>The answer is 353.3 g</u>. We know that aluminum is the limiting reactant, because the other one is in excess. To use the chemical equation, however, we must get the amount of aluminum in moles. The Periodic Table tells us aluminum has a mass of 26.98 amu, which also tells us:

$$1 \text{ mole Al} = 26.98 \text{ g Al}$$

Now we can convert to moles:

$$\frac{100.0 \; \cancel{\text{g Al}}}{1} \times \frac{1 \text{ mole Al}}{26.98 \; \cancel{\text{g Al}}} = 3.706 \text{ moles Al}$$

The equation tells us:

$$2 \text{ moles Al} = 3 \text{ moles Cu}$$

This allows us to convert to moles of Cu:

$$\frac{3.706 \; \cancel{\text{moles Al}}}{1} \times \frac{3 \text{ moles Cu}}{2 \; \cancel{\text{moles Al}}} = 5.559 \text{ moles Cu}$$

Unfortunately, we aren't done, because the problem asks for the amount of Cu in grams. Thus, we have to convert. The Periodic Table tells us Cu has a mass of 63.55 amu, which means:

$$1 \text{ mole Cu} = 63.55 \text{ g Cu}$$

We can use that to convert between moles and grams:

$$\frac{5.559 \; \cancel{\text{moles Cu}}}{1} \times \frac{63.55 \text{ g Cu}}{1 \; \cancel{\text{mole Cu}}} = 353.3 \text{ g Cu}$$

11. <u>The answer is 9.46 g</u>. In this reaction, we don't need to know the limiting reactant, because we are trying to find out how much of one reactant is needed. To do that, however, we must get the amount of water in moles:

$$\text{Mass of } H_2O = 2\times1.01 \text{ amu} + 16.00 \text{ amu} = 18.02 \text{ amu}$$

That means

$$1 \text{ mole } H_2O = 18.02 \text{ g } H_2O$$

We can use that to convert between grams and moles:

$$\frac{15.0 \cancel{\text{g } H_2O}}{1} \times \frac{1 \text{ mole } H_2O}{18.02 \cancel{\text{g } H_2O}} = 0.832 \text{ moles } H_2O$$

Now we can use the chemical equation to convert to NH_3:

$$6 \text{ moles } H_2O = 4 \text{ moles } NH_3$$

$$\frac{0.832 \cancel{\text{moles } H_2O}}{1} \times \frac{4 \text{ moles } NH_3}{6 \cancel{\text{moles } H_2O}} = 0.555 \text{ moles } NH_3$$

The problem wants to know the number of grams of NH_3, so there is still one conversion left:

$$\text{Mass of } NH_3 = 14.01 \text{ amu} + 3\times1.01 \text{ amu} = 17.04 \text{ amu}$$

This tells us:

$$1 \text{ mole } NH_3 = 17.04 \text{ g } NH_3$$

We can use that to convert between moles and grams:

$$\frac{0.555 \cancel{\text{moles } NH_3}}{1} \times \frac{17.04 \text{ g } NH_3}{1 \cancel{\text{mole } NH_3}} = 9.46 \text{ g } NH_3$$