ChemQuest 44

Percent Yield

Name: _____

Date: _____

Hour: _____

Information: Sources of Error in the Real World

When we perform experiments in the laboratory we never get all of the product we theoretically could get. Reactions in the laboratory are not ideal. For example, consider the reaction of sodium metal and chlorine gas to produce salt:

$$2\,Na + Cl_2 \rightarrow 2\,NaCl$$

If we react 23.0g of sodium metal with plenty of chlorine gas, calculations tell us that we should get about 58.5g of sodium chloride. However, if you tried this in the lab and then took the mass of your final product on a balance, you would usually get somewhat less than 58.5g. The more careful you are, the closer you can get to the mark of 58.5g, but you will never be able to make 58.5g of sodium chloride.

Critical Thinking Questions

1. What are some practical things—some "sources of error"—that can happen in the lab and in a reaction that would cause us to get less than 100% of the product that we are trying to produce?

   Spilling chemicals, weighing incorrectly, over-heating (human error)

2. The information section above made it sound like we always would get less than 58.5 g of salt. However, it is possible that after the reaction we could take the mass of the product and find that it is greater than 58.5g. According to our calculations this should be impossible, but what "sources of error" may cause this?

   weighing incorrectly, under-heating (human error)

3. When 40.5 g of sodium metal reacts with plenty of chlorine gas, how many grams of sodium chloride should be produced? (Note: when questions are worded this way, you automatically know that sodium is the limiting reactant.) mass – mass stoichiometry

$$40.5\,g\,Na \times \frac{1\,mol\,Na}{22.9\,g} \times \frac{2\,mol\,NaCl}{2\,mol\,Na} \times \frac{58.55\,g\,NaCl}{1\,mol\,NaCl} = 103\,g\,NaCl$$

Information: Calculating Percent Yield

Percent yield is a measure of how much of a product you actually obtained in a reaction compared to the amount that you *could have* obtained according to calculations. There is a handy formula for calculating percent yield:

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \bullet 100$$

"Theoretical yield" is the amount of a product that we should be able to make. You calculated the theoretical yield of sodium chloride in question 3; hopefully your answer was about 103g. Now let's say that you actually attempted this experiment in a lab with 40.5g of sodium and when you were finished you collected 84.0g of sodium chloride—this amount is your "actual yield", the amount of product you actually collected in the lab.

Using the formula given above, we can calculate our percent yield:

$$\text{percent yield} = \frac{84.0\text{g}}{103\text{g}} \bullet 100 = 81.6\%$$

Critical Thinking Questions

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

4. Consider the combustion of 215.0g of butane, C_4H_{10} with plenty of oxygen. If you are able to collect 295.3g of water in the laboratory, what was your percent yield. Hint: first calculate your theoretical yield using the balanced equation and mole ratios!

actual

$215.0\text{g}\,C_4H_{10} \times \frac{1\text{ mol}\,C_4H_{10}}{58.14\text{g}\,C_4H_{10}} \times \frac{10\text{ mol}\,H_2O}{2\text{ mol}\,C_4H_{10}} \times \frac{18.09\text{g}\,H_2O}{1\text{ mol}\,H_2O} = 332.8\text{g}\,H_2O$ ← theoretical

$\frac{295.3\text{g}}{332.8\text{g}} \times 100 = \boxed{88.7\%}$

$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

5. Consider the double replacement reaction of 104.7g of sodium chloride with ~~203.9g~~ of silver nitrate. If you are able to produce 150.4g of silver chloride what was your percent yield? (Hint: first find the limiting reactant!)

L.R.

$104.7\text{g}\,NaCl \times \frac{1\text{ mol}}{58.35\text{g}\,NaCl} = .0267\text{ mol}\,NaCl$ / 1

$203.9\text{g}\,AgNO_3 \times \frac{1\text{ mol}\,AgNO_3}{141.8\text{g}\,AgNO_3} = 1.44\text{ mol}\,AgNO_3$ / 1

$104.7\text{g}\,NaCl \times \frac{1\text{mol}\,NaCl}{58.35\text{g}\,NaCl} \times \frac{1\text{mol}\,AgCl}{1\text{mol}\,NaCl} \times \frac{143.25\text{g}\,AgCl}{1\text{mol}\,AgCl} = 257\text{g}\,AgCl$

$\frac{150.4}{257} \times 100 = \boxed{58.5\%}$

6. If you make 46.8g of calcium carbonate by reacting 87.5g of calcium nitrate with 98.6g of sodium carbonate, what is your percent yield?

$Ca(NO_3)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaNO_3$

$87.5\text{g}\,Ca(NO_3)_2 \times \frac{1\text{mol}\,Ca(NO_3)_2}{164.1\text{g}} \times \frac{1\text{ mol}\,CaCO_3}{1\text{ mol}\,Ca(NO_3)_2} \times \frac{100.09\text{g}}{1\text{ mol}\,CaCO_3} = 53.4\text{g}\,CaCO_3$

$\frac{46.8\text{g}}{53.4\text{g}} \times 100 = 87.6\%$