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| **Objectives** |
| * Describe quantitative changes in chemical reactions.
* Use the six steps to solve mass-mass problems.
* Use stoichiometry to determine the limiting reactant in a chemical reaction.

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**Stoichiometry:
a quantitative study of chemical changes.**

**The most common type of stoichiometry calculation is a mass-mass problem.**
The question looks like this: "given this amount of reactant, how much product will form?"

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| **Steps in solving a mass-mass problem**  |

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**1. Write a balanced equation for the reaction.
2. Write the given mass on a factor-label form.
3. Convert mass of reactant to moles of reactant.
4. Convert moles of reactant to moles of product.
5. Convert moles of product to grams of product.
6. Pick up the calculator and do the math.**



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| **Mass-Mass Sample Problem:** If iron pyrite, FeS2, is not removed from coal, oxygen from the air will combine with both the iron and the sulfur as coal burns. If a furnace burns an amount of coal containing 100 g of FeS2, how much SO2 (an air pollutant) is produced?

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| **1.** Write a balanced equation showing the formation of iron (III) oxide and sulfur dioxide.  |

**4FeS2 + 11O2 2 Fe2O3 + 8 SO2**

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| **2.** Write the mass information given in the problem.  |

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| **3.** Convert grams of FeS2 to moles of FeS2.  |

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| **4.** Changes moles of FeS2 (reactant) to moles of SO2 (product). This ratio comes from the **coefficients** in the balanced equation.Notice that the ratio was reduced from 8 **:** 4 to 2 **:** 1 when placed in the factor-label form. While reducing is not absolutely necessary (the ratio will cancel properly even if not reduced), a good chemistry student notices such things and will do it.  |

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| **5.** Convert moles of SO2 to grams of SO2 .  |

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| **6.** All units have been canceled except for grams of SO2 (product). The problem has been solved. Pick up the calculator and do the math.  |

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| **107 grams of SO2 will be produced.**  |

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**Limiting reactants**

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|  | **Limiting reactant: the reactant that is completely consumed in the reaction.** * The limiting reactant is not present in sufficient quantity to react with all other reactants.
* The reaction stops when the limiting reactant is completely consumed.
* Any remaining reactants are considered "excess reactants".
* The amount of product formed is determined by the "limiting reactant".
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| **Steps in solving a limiting reactant problem**  |

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**1.** Write a balanced equation for the reaction.
**2.** Convert both reactant quantities to moles.
**3.** Determine the moles of product that could be formed by each reactant.
**4.** The least amount in step #3 identifies the limiting reactant.
**5.** Use that number of moles of product to determine the mass produced.



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| **An example of a limiting reactant problem:** What mass of water can be produced by 4 grams of H2 reacting with 16 grams of O2?  |

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**Remember the following things about limiting reactants:**



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| The reaction will stop when the reactants are used up. If one reactant is used up before the other, the reaction stops then. The first reactant used up is the **limiting reactant**, use it for the calculation. The other reactant is the **excess reactant**, it is unimportant in the calculation. **The limiting reactant problem example:** What mass of water can be produced by 4g of H2 reacting with 16g of O2?  |

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| **The problem solution:**

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| **1.** Write a balanced equation for the reaction.  |
| 2 H2 + O2 2 H2O |
| **2.** Convert both reactant quantities to moles.  |
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| **3.** Using the mole ratio from the equation, determine the moles of water that could be formed by **each** reactant.  |
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| **4.** Oxygen produces the least amount of water. * + 16 grams of oxygen cannot produce as much water as 4 grams of hydrogen. In other words, 16 grams of oxygen will be used up in the reaction before 4 grams of hydrogen.
	+ Oxygen is the "limiting" reactant.
	+ Use oxygen for the calculation of product amount.
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| **5.** Complete the problem by converting moles of H2O to mass of H2O.  |  |
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| The **theoretical yield** for this problem is 18 grams. If you performed this reaction in the lab, your **actual yield** might be less. Can you think of reasons why?  |

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| **limiting reactant practice problems:** 1. Seventy five grams of calcium oxide react with one hundred thirty grams of hydrochloric acid to produce a salt and water. What is the limiting reactant?
2. How much aluminum oxide are produced when 46.5g of Al react with 165.37g of MnO?
3. Five grams of copper metal react with a solution containing twenty grams of silver nitrate to produce copper (II) nitrate and silver.
	1. What is the limiting reactant?
	2. How much of the limiting reactant would be needed to react completely with the given amount of excess reactant?
4. A solution containing 20.0 g of sodium sulfite reacts with 7.0 ml of phosphoric acid. The concentration of the acid solution is such that there are 1.83 grams of H3PO4 per milliliter of solution. Determine the following:
	1. The mass of the excess reactant remaining at completion.
	2. Grams of water produced.
	3. Moles of sodium phosphate produced.
	4. Grams of sulfur dioxide produced.
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  Answers

1 - calcium oxide
2. 79 g of aluminum oxide
3a - AgNO3
3b - 26.6 g AgNO3
4a -2.51 g H3PO4
4b - 2.85 g H2O
4c - 0.106 mole Na3PO4
4d - 10.15 g SO2

**Mass-Mass Practice Problems**

1. How many grams of silver chloride can be produced from the reaction of 20 g of silver nitrate with an excess amount of sodium chloride?
2. If an excess of nitrogen gas reacts with 5.2 g of hydrogen gas, how many grams of ammonia can be synthesized?
3. 6.5 grams of aluminum reacts with excess HCl to produce what mass of hydrogen gas?

**Bonus problems:**

* 1. How much oxygen gas can be produced by the decomposition of 200 grams of KClO3?
	2. What mass of water vapor is produced by the combustion of 500 grams of C2H6?
	3. What mass of silver is produced by the decomposition of 75 grams of silver sulfide?
	4. Barium sulfate is used in the "barium cocktail" given to patients prior to x-raying their intestinal tracts. Based on the following equation, a chemist began with 75.00 grams of Ba(NO3)2

Ba(NO3)2 (aq) + Na2SO4 (aq) BaSO4 (s) + 2NaNO3 (aq)

After collecting and drying the product, 64.45 grams of BaSO4 was obtained. What is the percentage yield of the reaction?

Answers to Mass-Mass Practice Problems

1.

2.

3.



A. 79g O2

B. 900g water vapor

C. 65g Ag

D. 96% Yield

D. 96% yield