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Part I: 'Mole to Mole' Conversions (1 conversion factor)

Fill in: Before starting any stoichiometry problem, you must have a ______________ chemical reaction equation. The coefficients in a balanced reaction equation tell us the relationship between the number of ___________ of each substance in the reaction. It does NOT tell us the relationship between the number of ___________ of each substance. (Choices: cookies, grams, chipmunks, moles, balanced, unbalanced)

Use the following balanced reaction equation to answer numbers 1-4: \( \text{Mg} + 2 \text{AgNO}_3 \rightarrow 2 \text{Ag} + \text{Mg(NO}_3)_2 \)

1. Write all of the possible mole ratios in the above reaction. There are six!
   a) \( \frac{2 \text{ mol AgNO}_3}{1 \text{ mol Mg}} \)
   b) 
   c) 
   d) 
   e) 
   f) 

'MOLE TO MOLE' EXAMPLE: If you start with 2 moles of Mg, how many moles of Ag can you make?
\[
\frac{2 \text{ mol Mg}}{1 \text{ mol Mg}} \times \frac{2 \text{ mol Ag}}{1 \text{ mol Mg}} = 4 \text{ mol Ag}
\]

2. How many moles of AgNO\(_3\) will you need if you want to make 6 moles of Mg(NO\(_3\))\(_2\) ?

3. You only have 5 moles of magnesium, how many moles of magnesium nitrate can you make?

4. How many moles of silver nitrate are needed to generate 20 moles of silver metal?

Use the following balanced reaction equation to answer numbers 5-7: \( 3 \text{O}_2 (g) + 4 \text{Al} (s) \rightarrow 2 \text{Al}_2\text{O}_3 (s) \)

5. How many moles of aluminum metal are needed to completely react with 8 moles of oxygen gas?

6. You combine 8 moles of oxygen gas with excess aluminum, how many moles of aluminum oxide can be produced? (Notice the wording.... use the moles of oxygen as your starting value.)

7. If you make 40 moles of aluminum oxide, how many moles of aluminum were used?

Balance the reaction equations for problems #8-11, then do stoichiometry!

8. _____ N\(_2\) + _____ H\(_2\) → _____ NH\(_3\)
   How many moles of hydrogen are needed to react with nitrogen and form 6.8 moles of ammonia?

9. _____ AgNO\(_3\) + _____ CaCl\(_2\) → _____ AgCl + _____ Ca(NO\(_3\))\(_2\)
   How many moles of silver nitrate react with 3.6 moles of calcium chloride?
10. _____ KOH + _____ FeCl₃ →
How many moles of iron (III) hydroxide are formed when 2 moles of potassium hydroxide react with iron (III) chloride?

11. _____ C₃H₈ + _____ O₂ →
How many moles of oxygen are needed for the complete combustion of 0.750 moles of propane (C₃H₈)?

**Part II: 'Mole to Mass' and 'Mass to Mole' Conversions (2 conversion factors)**

**Fill In:** The conversion factor used to covert between mass and moles is called ________________. This value is obtained from the ___________________. For a compound, the masses of the atoms must be added up to obtain the mass of the compound. Molar mass is the mass of ______ mole of an element or compound. The coefficients in balanced reaction equations ONLY tell the ratio of _______ of the substances, so molar mass is used whenever a question involves mass or grams. 'Mole to Mass' and 'Mass to Mole' problems always involve _______ conversion factors: the mole ratio and molar mass. The order they’re used in depends on the _____________. (Choices: chipmunks, moles, one, forty million, periodic table, infinite universe known as your memory, molar mass, cavity, two, zero, day of the week, problem)

12. Draw in the schematic used to “map” stoichiometry problems. Label the conversion factors used.

13. Look up or calculate the molar masses of the following, you will use them in the problems below. Use the exact values found on your periodic table for these problems.

   a) Al  
   b) O₂  
   c) AgNO₃  
   d) AgCl  
   e) Ca(NO₃)₂  
   f) H₂  
   g) N₂  
   h) Al₂O₃  
   i) CaCl₂  
   j) NH₃

**EXAMPLES:** These examples use the following balanced reaction equation: N₂ + 3 H₂ → 2 NH₃

**'MOLE TO MASS':** How many grams of ammonia (NH₃) can be made from 2 moles of hydrogen gas?

\[
2 \text{ mol H}_2 \times \frac{2 \text{ mol NH}_3}{3 \text{ mol H}_2} \times \frac{17 \text{ g NH}_3}{1 \text{ mol NH}_3} = 22.67 \text{ g NH}_3
\]

**'MASS TO MOLE':** How many moles of nitrogen gas are needed to make 8.5 grams of ammonia?

\[
8.5 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17 \text{ g NH}_3} \times \frac{1 \text{ mol N}_2}{2 \text{ mol NH}_3} = 0.25 \text{ mol N}_2
\]
14. How many grams of ammonia will be produced from 10 moles of nitrogen gas?

15. How many grams of nitrogen gas are needed to completely react with 3 moles of hydrogen gas?

16. If you have 20 moles of ammonia, what mass of hydrogen gas was used in the reaction?

17. How many moles of calcium chloride are needed to make 286.6 grams of silver chloride?

18. If you generate 71.66 grams of silver chloride, then how many moles of silver nitrate were used?

19. How many moles of calcium nitrate can you make if you have 679.5 grams of silver nitrate and excess calcium chloride?

20. What mass of aluminum is needed to generate 20 moles of aluminum oxide?

21. How many moles of oxygen are needed to completely react with 5 moles of aluminum?

22. If you have 20 moles of aluminum, how many grams of oxygen can you react?

23. In a single reaction 30 moles of oxygen gas are consumed. How many grams of aluminum oxide will be formed?

24. How many moles of aluminum are needed to react with 48 grams of oxygen gas so that there is nothing left over from either reactant?
Part III: 'Mass to Mass' Conversions (3 conversion factors)

Fill In: In 'Mass to Mass' stoichiometry problems you are given a mass of one substance in the problem and you need to _______ for the mass of ____________ substance. This is the biggest type of stoichiometry problem, because it uses _______ conversion factors. Two of the conversion factors are the ____________________ of the substances and the other is the _____________ given in the balanced reaction equation. A 'Mass to Mass' problem results in the _______________ of a substance. Remember, the relationship given in the reaction equation is between _________ of chemicals, NOT grams. You MUST convert grams to moles before using the mole _________. Also, don’t forget to include the chemical formulas and the ________ (i.e. “g” and “mol”) in the problem to help ensure it’s set up correctly. (Choices: guess, solve, flubber, another, three, 6.02x10²³, molar masses, colors, hamster ratio, mole ratio, theoretical yield, yield to pedestrians, moles, chicken, ratio, patio, units, beaker)

'MASS TO MASS' EXAMPLE: \( N_2 + 3 H_2 \rightarrow 2 NH_3 \)

How many grams of nitrogen gas are required to make 34 grams of ammonia?

\[
\begin{align*}
34 \text{ g } NH_3 & \times \frac{1 \text{ mol } NH_3}{17 \text{ g } NH_3} \times \frac{1 \text{ mol } N_2}{2 \text{ mol } NH_3} \times \frac{28 \text{ g } N_2}{1 \text{ mol } N_2} = 28 \text{ g } N_2
\end{align*}
\]

Note: You start with the molar mass of the substance with given information, then use mole ratio, then use the molar mass of the substance whose mass you’re solving for. The units should cancel out so that you’re left ONLY with grams of the second substance.

~ Use the following to answer the 'Mass to Mass' problems in #25-28: \( 2AgNO_3 + CaCl_2 \rightarrow 2AgCl + Ca(NO_3)_2 \)

25. How many grams of silver nitrate are needed to completely react with 221.8 grams of calcium chloride?

26. You want to make 286.6 grams of silver chloride. What mass of calcium nitrate will be generated in the process?

27. In a ten minute time span, 84.9 grams of silver nitrate is reacted. What is the theoretical yield of silver chloride (in other words, what mass of silver chloride will be produced)?

28. You have 0.17 kilograms of silver nitrate. How many grams of calcium chloride is needed to completely react this sample? (Hint: Convert kilograms to grams before starting the stoichiometry!)

Part IV: MIXED REVIEW

~ Use the following to answer #29-32: \( 3O_2 + 4 Al \rightarrow 2 Al_2O_3 \)

29. How many moles of aluminum oxide can be made from 8 moles of aluminum?

30. What mass of aluminum is needed to completely react with 32 grams of oxygen gas?
31. If 6 moles of oxygen reacts with an excess amount of aluminum, how many grams of aluminum oxide will be produced?

32. How many grams of oxygen gas is required to generate 102 grams of aluminum oxide?

~ Use the following to answer #33-35: \( N_2 + 3 H_2 \rightarrow 2 NH_3 \)

33. How many grams of hydrogen gas are required to synthesize 18 moles of ammonia?

34. Assume that nitrogen gas is the limiting reactant in the above reaction. What is the theoretical yield of ammonia if you start with 56 grams of nitrogen gas?

35. If 20 moles of nitrogen gas are available, how many moles of ammonia can be produced? How many moles of hydrogen gas will be consumed in the reaction?

**PART V: Percent Yield**

**Fill In:** In a real laboratory setting things _______ always work out perfectly. In a stoichiometry problem, you can determine the _______________ that would result from a reaction if it works out ideally. The _______________ is the amount that is really obtained. The actual yield can be _______________ than the theoretical yield, depending on things like contamination or loss of material during a step. The percent yield is the actual yield ____________ by the theoretical yield, then multiplied by one hundred. (Choices: do, do not, theoretical yield, run in a field, actual yield, power to wield, lawn mower, higher or lower, divided, multiplied)

**PERCENT YIELD EXAMPLE:** \( N_2 + 3 H_2 \rightarrow 2 NH_3 \)

You react 28 grams of nitrogen gas with excess hydrogen gas. You obtain 32 grams of ammonia in the process. What is your percent yield?

**FIRST STEP - CALCULATE THE THEORETICAL YIELD USING MASS TO MASS STOICHIOMETRY**

\[
\begin{align*}
28 \text{ g } N_2 \times \frac{1 \text{ mol } N_2}{28 \text{ g } N_2} \times \frac{2 \text{ mol } NH_3}{1 \text{ mol } N_2} \times \frac{17 \text{ g } NH_3}{1 \text{ mol } NH_3} &= 34 \text{ g } NH_3 \leftarrow \text{ theoretical yield!}
\end{align*}
\]

**SECOND STEP - DETERMINE PERCENT YIELD**

\[
\frac{32 \text{ grams } NH_3}{34 \text{ grams } NH_3} \times 100 = 94.1 \%
\]
36. You react 56 grams of nitrogen gas with an excess amount of hydrogen gas. You obtain 65 grams of ammonia. What is the percent yield for this reaction?

37. Over the course of five minutes, 20 grams of hydrogen gas is consumed. Assume that the hydrogen gas is the limiting reactant. If 110 grams of ammonia is collected from the reaction, what is the percentage yield?

38. Using the theoretical yield from #37...
   a) Calculate what the percentage yield would be if you obtained 115 grams of product.
   
   b) List two possible explanations for having a yield greater than 100%. Use complete sentences.
      i)
      ii)

39. In your most favorite class ever, Chemistry, you synthesize 15.5 grams of ammonia from 14 grams of nitrogen gas. What is your percentage yield?

40. Assuming the mass of ammonia product is accurate in #39, how many grams of hydrogen gas were used?