Stoichiometry

Unit: Stoichiometry

MA Curriculum Frameworks (2016): HS-PS1-7

Mastery Objective(s): (Students will be able to…)

- Solve mole-mole stoichiometry problems.

Success Criteria:

- For each compound in the chemical equation, the ratio of the coëfficients is the same as the ratio of the moles.
- Solutions have the correct quantities substituted for the correct variables.
- Algebra and rounding to appropriate number of significant figures is correct.

Tier 2 Vocabulary: mole, coëfficient

Language Objectives:

- Explain how the coefficients in a chemical equation are like the numbers in a pre-algebra "input-output machine."

Notes:

stoichiometry: measurement of how much of each reactant is used and how much of each product is produced in a chemical reaction.

stoichiometry problem: a chemistry problem in which you are given a balanced chemical equation and the quantity of one compound, and you are asked to find the quantity of another compound produced or consumed in the same equation.

For example, in the chemical reaction:

$$3\ CaCl_2 + 2\ Na_3PO_4 \rightarrow 6\ NaCl + Ca_3(PO_4)_2$$

3 molecules of $CaCl_2$ would produce 1 molecule of $Ca_3(PO_4)_2$. Because a mole is always the same number of molecules, this means 3 moles of $CaCl_2$ produces 1 mole of $Ca_3(PO_4)_2$.

Stoichiometry is simply the process of using the coëfficients in a balanced chemical equation to convert from moles of one compound to moles of another.

Use this space for summary and/or additional notes:

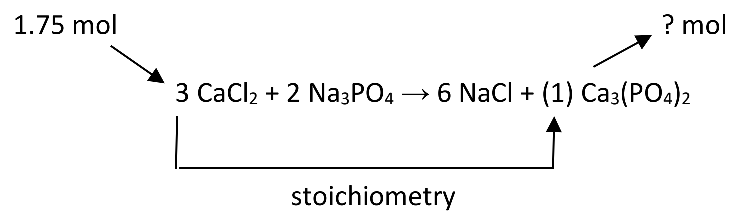
Sample problem:

Q: Suppose 1.75 mol of $CaCl_2$ reacts according to the following equation:

$$3\ CaCl_2 + 2\ Na_3PO_4 \rightarrow 6\ NaCl + Ca_3(PO_4)_2$$

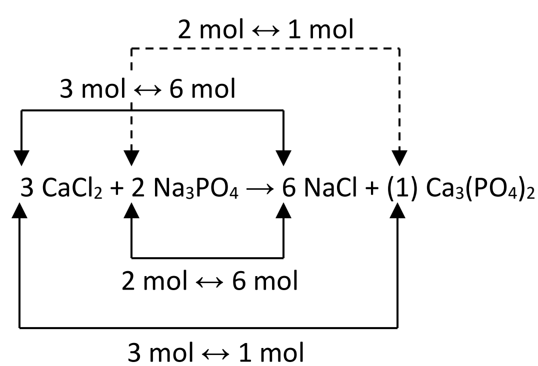
How many moles of $Ca_3(PO_4)_2$ would be produced?

A: What makes this a stoichiometry problem is that you are "coming into the equation" with information about the amount of one compound (4.5 mol of $CaCl_2$), and you are being asked to find the amount of a different compound (how many moles of $Ca_3(PO_4)_2$).



The coefficients (3 $CaCl_2$ and 1 $Ca_3(PO_4)_2$) are in a 3:1 ratio. This means the moles of $CaCl_2$ reacted : $Ca_3(PO_4)_2$ produced must always be in a 3:1 ratio.

In the equation above, we can use *any pair* of coëfficients to make a conversion factor. There are eight possible conversion factors you could get from the equation $3\ CaCl_2 + 2\ Na_3PO_4 \rightarrow 6\ NaCl + Ca_3(PO_4)_2$.



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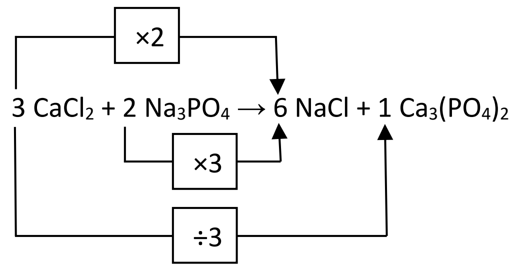
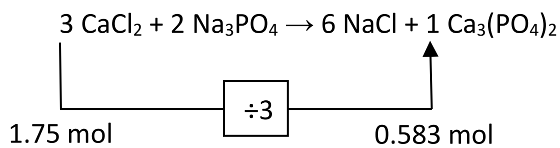
In elementary school, you may have been taught pre-algebra problems using "input/output machines". For example, a "times 2 machine" would multiply anything that goes through it by 2:

3.4 mol → [×2] → 6.8 mol

Getting from one coefficient to another is just like using one of those multiplication or division "machines":



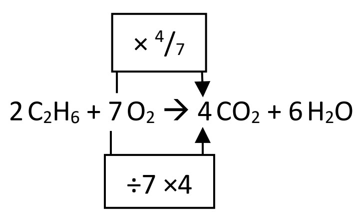
For example, suppose we had 1.75 mol of $CaCl_2$ and we wanted to know how much $Ca_3(PO_4)_2$ would be made.



1.75 mol $CaCl_2$ ÷ 3 = 0.583 mol $Ca_3(PO_4)_2$

Sometimes it's easier to think of the stoichiometry "machine" as a sequence of division and multiplication "machines".

In the following example, we can get from moles of O_2 to moles of CO_2 either in one step (the top pathway) by multiplying by $^4/_7$, or in two steps (the bottom pathway) by dividing by 7 (to get rid of the old coëfficient) and then multiplying by 4 (to get the new one).



For example, if we started with 15.4 mol O_2, the "machines" tell us that:

15.4 mol O_2 → [× $^4/_7$] → 8.8 mol CO_2 or 15.4 mol O_2 → [÷7] → [×4] → 8.8 mol CO_2

Use this space for summary and/or additional notes:

Homework Problems

1. Determine how much of each product would be made when 4.0 mol of $Pb(NO_3)_2$ decomposes in the reaction: $2\ Pb(NO_3)_2 \rightarrow 2\ PbO + 4\ NO_2 + O_2$

   Answer: 4.0 mol PbO; 8.0 mol NO_2; 2.0 mol O_2

2. Determine how much of each product would be made when 1.33 mol of Ca_3P_2 reacts with excess water in the reaction:
   $Ca_3P_2 + 6\ H_2O \rightarrow 3\ Ca(OH)_2 + 2\ PH_3$

   Answer: 3.99 mol $Ca(OH)_2$; 2.66 mol PH_3

3. Determine how much $AlCl_3$ would you need to completely react with 1.5 mol Ca in the reaction: $3\ Ca + 2\ AlCl_3 \rightarrow 3\ CaCl_2 + 2\ Al$

   Answer: 1.0 mol $AlCl_3$

4. Determine how much of each product would be made when 1.50 mol H_3PO_3 decomposes in the reaction: $4\ H_3PO_3 \rightarrow 3\ H_3PO_4 + PH_3$

   Answer: 1.13 mol H_3PO_4; 0.375 mol PH_3

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5. Determine how many moles of KCl would be produced from 0.175 mol of K and excess Cl_2 in the reaction: $2\,K + Cl_2 \rightarrow 2\,KCl$

   Answer: 0.175 mol KCl

6. Determine how many moles of Na_2O would be required to produce 0.275 mol of NaOH in the reaction: $Na_2O + H_2O \rightarrow 2\,NaOH$

   Answer: 0.138 mol Na_2O

7. Determine how many moles of O_2 will be produced by 8.75 mol of $NaClO_3$ in the reaction: $2\,NaClO_3 \rightarrow 2\,NaCl + 3\,O_2$

   Answer: 26.3 mol O_2

8. Determine how many moles of NaCl are produced in the following reaction when 45.4 L of O_2 are produced at S.T.P. in the reaction:
   $2\,NaClO_3 \rightarrow 2\,NaCl + 3\,O_2$
   (*Hint: you will need to convert* 45.4 L *of gas at S.T.P. into moles first.*)

   Answer: 1.33 mol NaCl

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