

Stoichiometry





Stoichiometry

- The word stoichiometry derives from two Greek words:
 - *Stoicheion* (meaning "element")
 - *Metron* (meaning "measure")
- Stoichiometry deals with calculations about the masses (sometimes volumes) of reactants and products involved in a chemical reaction.
- The most common stoichiometric problem will present you with a certain **amount of reactant** and then ask **how much product can be formed**.



Stoichiometry

Here is a generic chemical equation



- For every **2 moles** of A used, **3 moles** of C are formed
- For every **2 moles** of B used, then **3 moles** of C are formed.

$$\frac{n(B)}{n(C)} = \frac{2}{3}$$

- e.g. if 6 moles of C are formed, then 4 moles of B are used.

$$n(B) = 6 \times \frac{2}{3} = 4$$



Writing Mole Ratios

- Let's look at another equation:



- The exact molar ratio you would use depends on how the problem is worded.
 - What is the molar ratio between O_3 and O_2 ? $\frac{2}{3}$ or $2 : 3$
 - What is the molar ratio between O_2 and O_3 ? $\frac{3}{2}$ or $3 : 2$
 - Often the mass of chemicals are given and they must be converted to moles before the question can be completed
- Typical question:** Given 20.0g of A and sufficient B, how many grams of C can be produced?



Steps for solving Mass-Mass Stoichiometry Problems

1. Make sure the chemical equation is correctly **balanced**.
2. Underneath the compound in the equation and using the molar mass of the given substance, **convert** the **mass** given in the problem **to moles**
3. Construct a **molar proportion/ratio**. Use it to determine the number of moles of the unknown
4. Using the molar mass of the unknown substance, **convert moles** of the unknown **to mass**.



Sample Problem#1

Calculate the mass of nitrogen needed to produce 1000.0 g of ammonia gas.

$$\begin{array}{lcl} 1\text{N}_{2(g)} + 3\text{H}_{2(g)} & \square & 2\text{NH}_{3(g)} \\ \text{unknown } n(\text{N}_2) & & m=1000.0\text{g} \\ \text{known } n(\text{NH}_3) & = \frac{1}{2} & M = 17.0 \text{ g/mol} \\ n = \frac{1}{2}(58.82 \text{ mol}) & n = m/M & \\ & = 1000.0\text{g} / 17.0\text{g/mol} & \\ & = 58.82 \text{ mol (1 extra SF)} & \end{array}$$

$= 29.41 \text{ mol N}_2$

Convert moles of N₂ to mass

$$m = n \times M \quad M(\text{N}_2) = 2 \times 14.0 = 28.0 \text{ g/mol}$$

$$\begin{aligned} m &= 29.41 \text{ mol} \times 28.0 \text{ g/mol} \\ &= 823.48 \end{aligned}$$

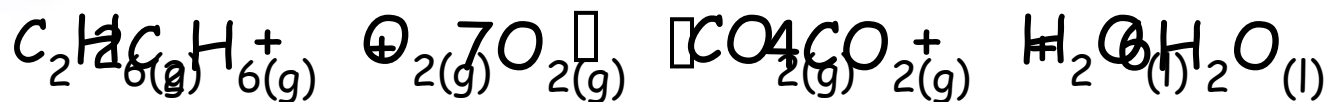
$$= 824 \text{ g (3 sig digits)}$$

\therefore 824 grams of N₂ are required.



Sample Problem#2

- Calculate the mass of water produced when 300.0 g of ethane is burned in excess oxygen.



$$m = 300.0 \text{ g}$$

$$M = 30.0 \text{ g/mol}$$

$$n = m/M$$

$$= 300.0 \text{ g} / 30.0 \text{ g/mol}$$

$$= 10.00 \text{ mol (1 extra SF)}$$

$$\frac{n(\text{H}_2\text{O})}{n(\text{C}_2\text{H}_6)} = \frac{6}{2}$$

$$\begin{aligned} n(\text{H}_2\text{O}) &= 10.00 \text{ mol} \times \frac{6}{2} \\ &= 30.0 \text{ mol H}_2\text{O} \end{aligned}$$

Convert moles of H₂O to mass

$$m = n \times M \quad M(\text{H}_2\text{O}) = 2 \times 1.0 + 16.0 = 18.0 \text{ g/mol}$$

$$m = 30.0 \text{ mol} \times 18.0 \text{ g/mol}$$

$$= 540.0 \text{ g}$$

$$= 5.40 \times 10^2 \text{ g (3 sig digits)}$$

∴ 540 grams of H₂O will be produced.