

# Stoichiometry

# Stoichiometry

- Consider:  $4\text{NH}_3 + 5\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{NO}$
- Recall that many conversion factors exist:  
4 mol  $\text{NH}_3$ /5 mol  $\text{O}_2$ , 6 mol  $\text{H}_2\text{O}$ /4 mol  $\text{NH}_3$ , etc
- In words, this tells us that for every 4 moles of  $\text{NH}_3$ , 5 moles of  $\text{O}_2$  are required, etc.
- “Stoichiometry” refers to the relative quantities of moles. It also refers to calculations that make use of mole ratios.
- Recall also that molar masses provide factors:
- 1 mol  $\text{NH}_3$  / 17 g  $\text{NH}_3$ , 32 g  $\text{O}_2$  / 1 mol  $\text{O}_2$
- Is 4 g  $\text{NH}_3$  / 5 g  $\text{O}_2$  a conversion factor?
- No. The equation tells us moles not grams.
- Notice that stoichiometry requires precision

# Stoichiometry questions (1)

Consider :  $4\text{NH}_3 + 5\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{NO}$

- How many moles of  $\text{H}_2\text{O}$  are produced if 0.176 mol of  $\text{O}_2$  are used?

$$\# \text{ mol H}_2\text{O} = 0.176 \text{ mol O}_2 \times \frac{6 \text{ mol H}_2\text{O}}{5 \text{ mol O}_2} = 0.2112 \text{ mol H}_2\text{O}$$

- How many moles of  $\text{NO}$  are produced in the reaction if 17 mol of  $\text{H}_2\text{O}$  are also produced?

$$\# \text{ mol NO} = 17 \text{ mol H}_2\text{O} \times \frac{4 \text{ mol NO}}{6 \text{ mol H}_2\text{O}} = 11.33 \text{ mol NO}$$

Notice that a correctly balanced equation is essential to get the right answer

# Stoichiometry questions (2)

Consider :  $4\text{NH}_3 + 5\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{NO}$

- How many grams of  $\text{H}_2\text{O}$  are produced if 1.9 mol of  $\text{NH}_3$  are combined with excess oxygen?

# g  $\text{H}_2\text{O}$ =

$$1.9 \text{ mol } \cancel{\text{NH}_3} \times \frac{6 \text{ mol } \cancel{\text{H}_2\text{O}}}{4 \text{ mol } \cancel{\text{NH}_3}} \times \frac{18.02 \text{ g } \cancel{\text{H}_2\text{O}}}{1 \text{ mol } \cancel{\text{H}_2\text{O}}} = 51.4 \text{ g } \text{H}_2\text{O}$$

- How many grams of  $\text{O}_2$  are required to produce 0.3 mol of  $\text{H}_2\text{O}$ ?

# g  $\text{O}_2$ =

$$0.3 \text{ mol } \cancel{\text{H}_2\text{O}} \times \frac{5 \text{ mol } \cancel{\text{O}_2}}{6 \text{ mol } \cancel{\text{H}_2\text{O}}} \times \frac{32 \text{ g } \cancel{\text{O}_2}}{1 \text{ mol } \cancel{\text{O}_2}} = 8 \text{ g } \text{O}_2$$

# Stoichiometry questions (3)

Consider :  $4\text{NH}_3 + 5\text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{NO}$

- How many grams of NO is produced if 12 g of  $\text{O}_2$  is combined with excess ammonia?

# g NO =

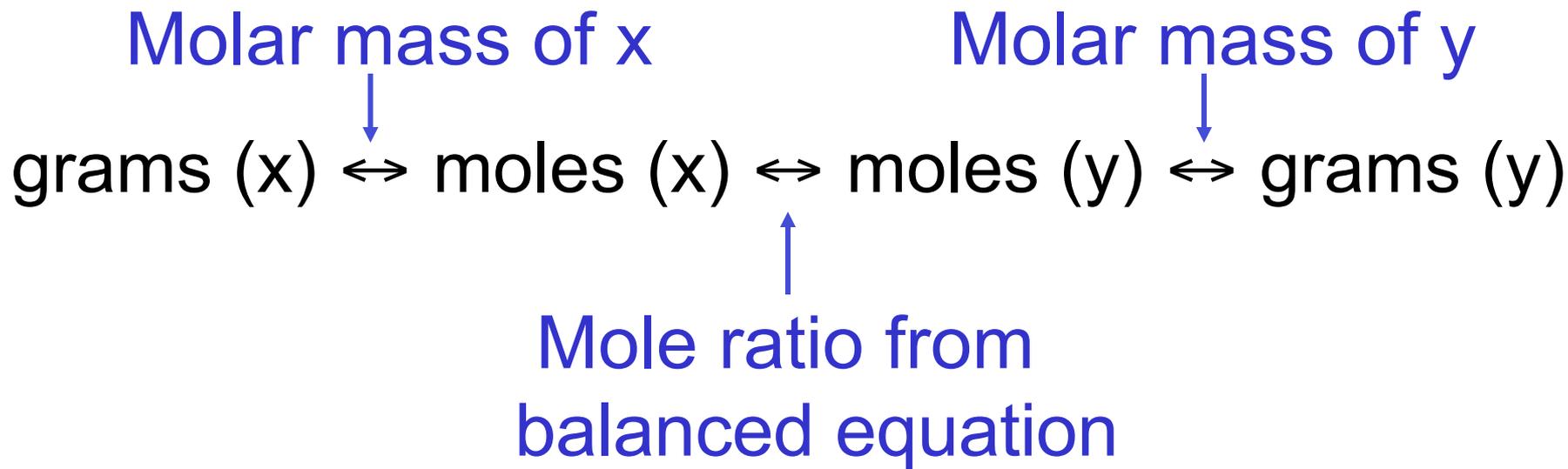
$$12 \text{ g } \cancel{\text{O}_2} \times \frac{1 \cancel{\text{ mol O}_2}}{32 \cancel{\text{ g O}_2}} \times \frac{4 \cancel{\text{ mol NO}}}{5 \cancel{\text{ mol O}_2}} \times \frac{30.01 \text{ g NO}}{1 \cancel{\text{ mol NO}}} = 9.0 \text{ g NO}$$

# Converting grams to grams

- Notice that we cannot directly convert from grams of one compound to grams of another. Instead we have to go through moles.
  - Many stoichiometry problems follow a pattern:  
**grams(x)  $\leftrightarrow$  moles(x)  $\leftrightarrow$  moles(y)  $\leftrightarrow$  grams(y)**
  - We can start anywhere along this path depending on the question we want to answer
- Q- for the reaction  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$  what is the path we would take for the following
- Given 2 moles  $\text{H}_2\text{O}$ , calculate grams  $\text{H}_2\text{O}$ ?
  - **Moles  $\text{O}_2$  required for 36 g  $\text{H}_2$ ?**
  - Grams of  $\text{H}_2\text{O}$  produced from 6 grams  $\text{O}_2$ ?

# Moving along the stoichiometry path

- We always use the same type of information to make the jumps between steps:



- a) How many moles of  $\text{H}_2\text{O}$  can be made using 0.5 mol  $\text{NH}_3$ ?  
b) what mass of  $\text{NH}_3$  is needed to make 1.5 mol  $\text{NO}$ ?  
c) how many grams of  $\text{NO}$  can be made from 120 g of  $\text{NH}_3$ ?

# Answers



a)

$$\# \text{ mol H}_2\text{O} = 0.5 \text{ mol } \cancel{\text{NH}_3} \times \frac{6 \text{ mol H}_2\text{O}}{4 \cancel{\text{ mol NH}_3}} = 0.75 \text{ mol H}_2\text{O}$$

b)

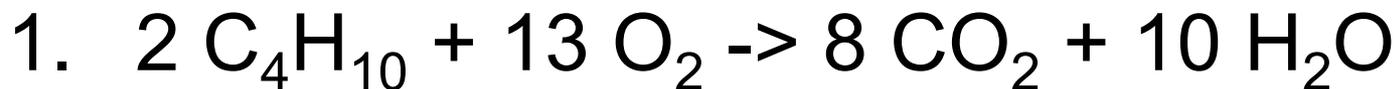
$$\# \text{ g NH}_3 = 1.5 \cancel{\text{ mol NO}} \times \frac{4 \cancel{\text{ mol NH}_3}}{4 \cancel{\text{ mol NO}}} \times \frac{17.04 \text{ g NH}_3}{1 \cancel{\text{ mol NH}_3}} = 25.6 \text{ g NH}_3$$

c)

$$\# \text{ g NO} = 120 \cancel{\text{ g NH}_3} \times \frac{1 \cancel{\text{ mol NH}_3}}{17.04 \cancel{\text{ g NH}_3}} \times \frac{4 \cancel{\text{ mol NO}}}{4 \cancel{\text{ mol NH}_3}} \times \frac{30.01 \text{ g NO}}{1 \cancel{\text{ mol NO}}} = 211 \text{ g NO}$$

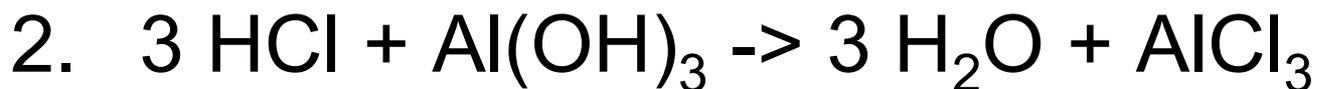
# More Stoichiometry Questions

Follow the rules for significant digits. Show all calculations.

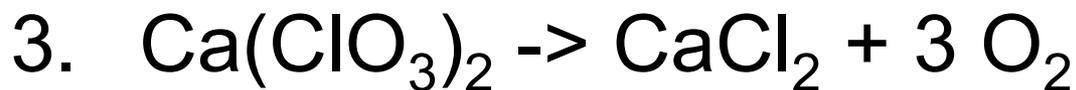


a) what mass of  $\text{O}_2$  will react with 400 g  $\text{C}_4\text{H}_{10}$ ?

b) how many moles of water are formed in a)?



How many grams of aluminum hydroxide will react with 5.3 moles of HCl?



What mass of  $\text{O}_2$  results from the decomposition of 1.00 kg of calcium chlorate?

4. The reaction of Ca with water can be predicted using the activity series. What mass of water is needed to completely react with 2.35 g of Ca?



- a) How many moles of carbon monoxide are required to react with 163.0 g of iron(III) oxide?
- b) How many grams of  $\text{CO}_2$  are produced from a reaction that also produces 23.9 grams of Fe?



- a) how many moles of copper(II) nitrate can be prepared from 17.0 moles of Cu?
- b) how many grams of copper(II) nitrate can be prepared using 3.8 moles of  $\text{HNO}_3$ ?
- c) what mass of water results from the reaction of 8.50 kg of copper metal?