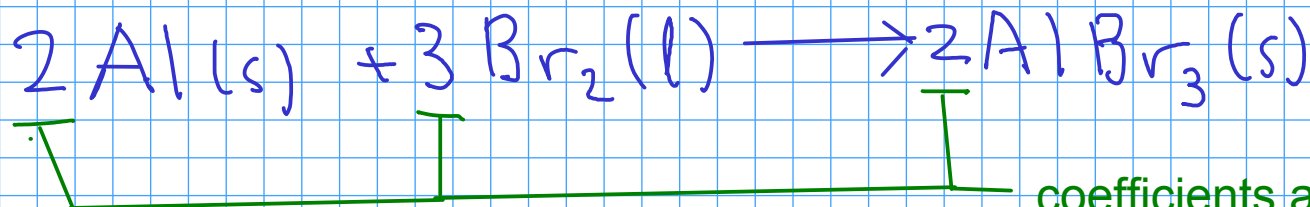


CHEMICAL CALCULATIONS CONTINUED: REACTIONS

- Chemical reactions proceed on an ATOMIC basis, NOT a mass basis!
- To calculate with chemical reactions (i.e. use chemical equations), we need everything in terms of ATOMS ... which means MOLES of atoms



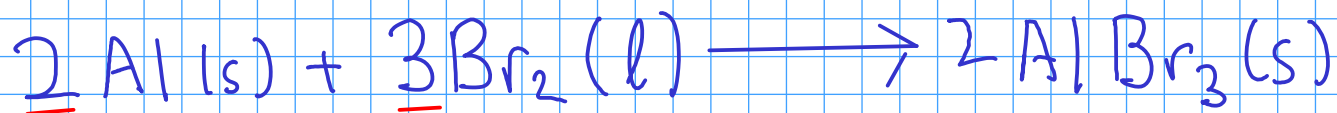
coefficients are in terms of atoms and molecules!

2 atoms Al = 3 molecules Br₂ = 2 formula units AlBr₃

2 mol Al = 3 mol Br₂ = 2 mol AlBr₃ *

- To do chemical calculations, we need to:

- ① - Relate the amount of substance we know (mass or volume) to a number of moles
- ② - Relate the moles of one substance to the moles of another using the equation
- ③ - Convert the moles of the new substance to mass or volume as desired

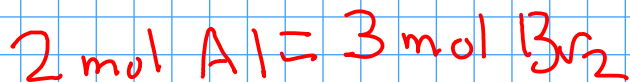


* Given that we have 25.0 g of liquid bromine, how many grams of aluminum would we need to react away all of the bromine? How many grams of aluminum bromide would be produced?

(1) Convert grams of bromine to moles: Need formula weight $\text{Br}_2 : \frac{2 \times 79.90}{159.80}$
 $159.80 \text{ g Br}_2 = 1 \text{ mol Br}_2$

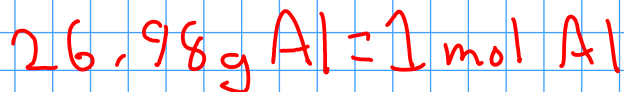
$$25.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.80 \text{ g Br}_2} = 0.15645 \text{ mol Br}_2$$

(2) Use the chemical equation to relate moles of bromine to moles of aluminum



$$0.15645 \text{ mol Br}_2 \times \frac{2 \text{ mol Al}}{3 \text{ mol Br}_2} = 0.10430 \text{ mol Al}$$

(3) Convert moles aluminum to mass: Need formula weight $\text{Al} : 26.98$



$$0.10430 \text{ mol Al} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = \boxed{2.81 \text{ g Al}}$$

You can combine all three steps on one line if you like!

$$25.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.80 \text{ g Br}_2} \times \frac{2 \text{ mol Al}}{3 \text{ mol Br}_2} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = 2.81 \text{ g Al}$$

(1) (2) (3)

$$\begin{array}{r} 25.0 \text{ g Br}_2 \\ + 2.81 \text{ g Al} \\ \hline 27.8 \text{ g AlBr}_3 \end{array}$$

Conservation of mass!

But ...

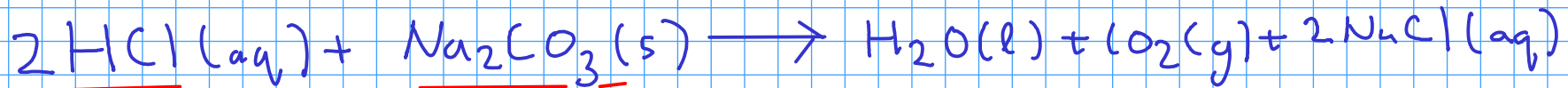
...what would you have done to calculate the mass of aluminum bromide IF you had NOT been asked to calculate the mass of aluminum FIRST?

$$25.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.8 \text{ g Br}_2} \times \frac{2 \text{ mol AlBr}_3}{3 \text{ mol Br}_2} \times \frac{266.68 \text{ g AlBr}_3}{1 \text{ mol AlBr}_3} = 27.8 \text{ g AlBr}_3$$

$$\begin{array}{l} \text{AlBr}_3: \text{ Al} : 1 \times 26.98 \\ \text{Br} : 3 \times 79.90 \\ \hline 266.68 \end{array}$$

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?



- ① - Convert mass of sodium carbonate to moles using formula weight
- ② - Convert moles of sodium carbonate to moles hydrochloric acid using chemical equation
- ③ - Convert moles of hydrochloric acid to volume using concentration (M = moles/L)

① - Convert mass of sodium carbonate to moles using formula weight

$$105.99 \text{ g Na}_2\text{CO}_3 = 1 \text{ mol Na}_2\text{CO}_3$$

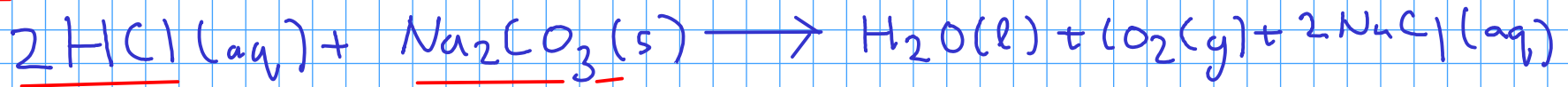
$$\begin{array}{l} \text{Na} : 22.99 \times 2 \\ \text{C} : 12.01 \times 1 \\ \text{O} : 16.00 \times 3 \\ \hline 105.99 \end{array}$$

$$25.0 \text{ g Na}_2\text{CO}_3 \times \frac{1 \text{ mol Na}_2\text{CO}_3}{105.99 \text{ g Na}_2\text{CO}_3} = 0.2359 \text{ mol Na}_2\text{CO}_3$$

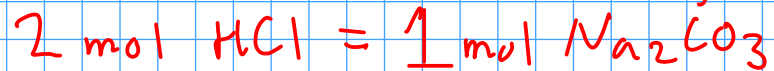
①

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?



② - Convert moles of sodium carbonate to moles hydrochloric acid using chemical equation



$$0,2359 \text{ mol Na}_2\text{CO}_3 \times \frac{2 \text{ mol HCl}}{1 \text{ mol Na}_2\text{CO}_3} = 0,4717 \text{ mol HCl}$$

②

③ - Convert moles of hydrochloric acid to volume using concentration (M = moles/L)

$$6,00 \text{ mol HCl} = 1 \text{ L}$$

$$0,4717 \text{ mol HCl} \times \frac{1 \text{ L}}{6,00 \text{ mol HCl}} = 0,0786 \text{ L HCl solution}$$

③

$$1 \text{ L} = 10^{-3} \text{ L}$$

Convert L to mL, since the problem statement asks us to find the mL of acid solution required.

$$0,0786 \text{ L} \times \frac{10^3 \text{ mL}}{1 \text{ L}} = \boxed{78,6 \text{ mL of } 6,00 \text{ M HCl}}$$