

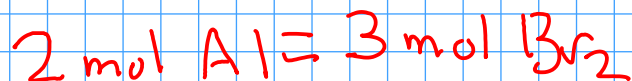
\* Given that we have 25.0 g of liquid bromine, how many grams of aluminum would we need to react away all of the bromine? How many grams of aluminum bromide would be produced?

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

$$159.80 \text{ g Br}_2 = 1 \text{ mol Br}_2$$

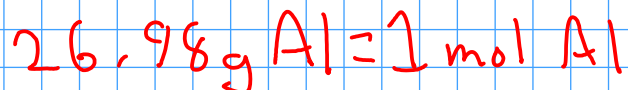
$$25.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.80 \text{ g Br}_2} = 0.15645 \text{ mol Br}_2$$

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)

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

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?

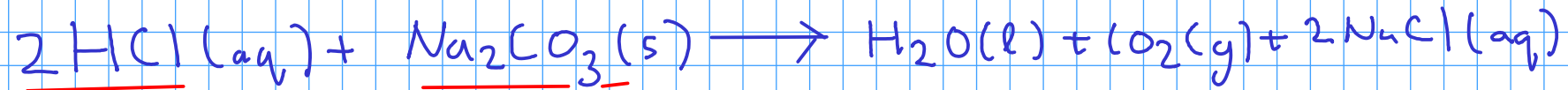
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$$25.0 \text{ g Br}_2 \times \frac{1 \text{ mol Br}_2}{159.8 \text{ g Br}_2} \times \frac{2 \text{ mol AlBr}_3}{3 \text{ mol Br}_2} \times \frac{266.68 \text{ g AlBr}_3}{1 \text{ mol AlBr}_3} = 27.8 \text{ g AlBr}_3$$

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

Example:

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



- Convert mass of sodium carbonate to moles using formula weight
  - Convert moles of sodium carbonate to moles hydrochloric acid using chemical equation
  - Convert moles of hydrochloric acid to volume using concentration ( $M = \text{moles/L}$ )
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- Convert mass of sodium carbonate to moles using formula weight

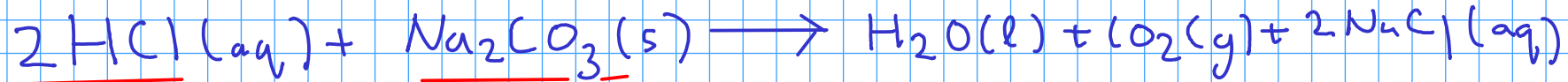
$$\begin{array}{l} \text{Na}_2\text{CO}_3: \quad \text{Na} : 2 \times 22.99 \\ \quad \quad \quad \text{C} : 1 \times 12.01 \\ \quad \quad \quad \text{O} : 3 \times 16.00 \\ \hline \quad \quad \quad 105.99 \end{array}$$

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

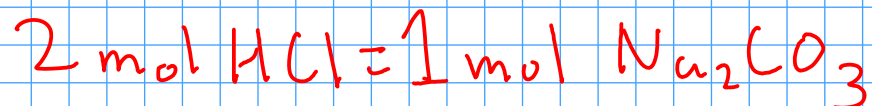
$$25.0 \text{ g Na}_2\text{CO}_3 \times \frac{1 \text{ mol Na}_2\text{CO}_3}{105.99 \text{ g Na}_2\text{CO}_3} = 0.235871 \text{ mol Na}_2\text{CO}_3$$

Example:

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



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



$$0,235871 \text{ mol Na}_2\text{CO}_3 \times \frac{2 \text{ mol HCl}}{1 \text{ mol Na}_2\text{CO}_3} = 0,471743 \text{ mol HCl}$$

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

$$6.00 \text{ M HCl}: \quad 6.00 \text{ mol HCl} = 1 \text{ L}$$

$$0,471743 \text{ mol HCl} \times \frac{1 \text{ L}}{6.00 \text{ mol HCl}} = 0,0786 \text{ L of solution}$$

$\text{mL} = 10^{-3} \text{ L}$  Convert liters to milliliters!

$$0,0786 \text{ L of solution} \times \frac{\text{mL}}{10^{-3} \text{ L}} = \boxed{78,6 \text{ mL solution}}$$

## EXAMPLE PROBLEM:



How many grams of sodium metal is required to completely react with 2545 grams of chlorine gas? ① Convert 2545g Cl<sub>2</sub> to moles, need FW 2x35.45 = 70.90

② Convert mol Cl<sub>2</sub> to moles Na, need equation: 2 mol Na = 1 mol Cl<sub>2</sub>

③ Convert mol Na to mass, need FW: 22.99 g/mol

$$\begin{array}{ccc} 70.90 \text{ g Cl}_2 = 1 \text{ mol Cl}_2 & | & 2 \text{ mol Na} = 1 \text{ mol Cl}_2 & | & 22.99 \text{ g Na} = 1 \text{ mol Na} \\ \textcircled{1} & & \textcircled{2} & & \textcircled{3} \end{array}$$

$$2545 \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.90 \text{ g Cl}_2} \times \frac{2 \text{ mol Na}}{1 \text{ mol Cl}_2} \times \frac{22.99 \text{ g Na}}{1 \text{ mol Na}} = 1650. \text{ g Na}$$

①                      ②                      ③

EXAMPLE PROBLEM:



How many mL of 0.250 M sodium hydroxide is required to completely react with 15.0 mL of 2.00 M sulfuric acid?

Convert to liters, since molarity (M) is based on liters!

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

$$15.0 \text{ mL} \times \frac{10^{-3} \text{L}}{\text{mL}} = 0.0150 \text{ L H}_2\text{SO}_4$$

This is the initial amount of sulfuric acid expressed in liters.

① convert 15.0 mL of 2.00 M  $\text{H}_2\text{SO}_4$  to moles  $2.00 \text{ mol H}_2\text{SO}_4 = 1 \text{ L}$

② convert mol  $\text{H}_2\text{SO}_4$  to mol  $\text{NaOH}$ :  $1 \text{ mol H}_2\text{SO}_4 = 2 \text{ mol NaOH}$

③ convert mol  $\text{NaOH}$  to volume 0.250 M  $\text{NaOH}$

$$0.250 \text{ mol NaOH} = 1 \text{ L}$$

$$2.00 \text{ mol H}_2\text{SO}_4 = 1 \text{ L} \quad \text{①}$$

$$1 \text{ mol H}_2\text{SO}_4 = 2 \text{ mol NaOH} \quad \text{②}$$

$$0.250 \text{ mol NaOH} = 1 \text{ L} \quad \text{③}$$

$$0.0150 \text{ L H}_2\text{SO}_4 \times \frac{2.00 \text{ mol H}_2\text{SO}_4}{1 \text{ L}} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1 \text{ L}}{0.250 \text{ mol NaOH}} = 0.240 \text{ L}$$

Answer asks for mL, so convert liters to mL.

$$\text{mL} = 10^{-3} \text{L} \quad \left| \quad 0.240 \text{ L} \times \frac{\text{mL}}{10^{-3} \text{L}} = 240. \text{ mL of } 0.250 \text{ M NaOH} \right.$$