Homework Assignments:

- Chapter 3 HW due September 20, 11:55 pm
- Chapter 4 HW due September 26, 11:55 pm
- Quiz 2 (Covers the Chapters 3 and 4) will post this Friday and due Monday 11:59 pm
- Exam 1 will be on September 26 (Wednesday), 50 minutes (20 - 25 MCQs), covers chapters 1, 2, 3, and 4

- Stoichiometry workshop is today from 5:00 – 7:00 pm at IST 1065.

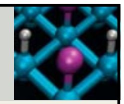
19

Percent Yield

$$\text{Percentage Yield} = \left(\frac{\text{actual yield}}{\text{theoretical yield}}\right) \times 100\%$$

- Percent yield is the amount of the actual yield compared to the theoretical yield.
  - ✓ Measures reaction efficiency
  - ✓ When you perform a laboratory experiment, the amount of product collected is the ***actual yield***.
  - ✓ The amount of product calculated based on the limiting reactant is the ***theoretical yield***.

20



Calculating Percent Yield

- Suppose a student performs a reaction and obtains 0.875 g of $CuCO_3$ and the theoretical yield is 0.988 g. What is the percent yield?

$Cu(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow CuCO_3(s) + 2\ NaNO_3(aq)$

$$\text{Percentage Yield} = \left(\frac{\text{actual yield}}{\text{theoretical yield}}\right) \times 100\%$$

$$\frac{0.875\ \text{g}\ \cancel{CuCO_3}}{0.988\ \text{g}\ \cancel{CuCO_3}} \times 100\ \% \quad = 88.6\ \%$$

- The percent yield obtained is 88.6%.

21

Example Problem

7) In a laboratory experiment, a student heats 42.0 g of $NaHCO_3$ and determines that 22.3 g of Na_2CO_3 is formed. What is the percentage yield of this reaction?

$$2NaHCO_3(s) \xrightarrow{\text{heat}} Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Theoretical yield of Na_2CO_3,

$$42.0\ \text{g} \times \frac{1\ \text{mol NaHCO}_3}{84.0\ \text{g NaHCO}_3} \times \frac{1\ \text{mol Na}_2\text{CO}_3}{2\ \text{mol NaHCO}_3} \times \frac{106.0\ \text{g Na}_2\text{CO}_3}{1\ \text{mol Na}_2\text{CO}_3} = 26.5\ \text{g Na}_2\text{CO}_3$$

Then calculate the percent yield,

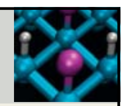
$$\begin{aligned}\text{Percentage yield} &= \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% \\ &= \frac{22.3\ \text{g}}{26.5\ \text{g}} \times 100\% \\ &= 84.2\%\end{aligned}$$

8) How many grams of $KClO_3$ are needed to produce 42.0 g of O_2 if the percentage yield is 65.0%?
   $2KClO_3 \rightarrow 2KCl + 3O_2$

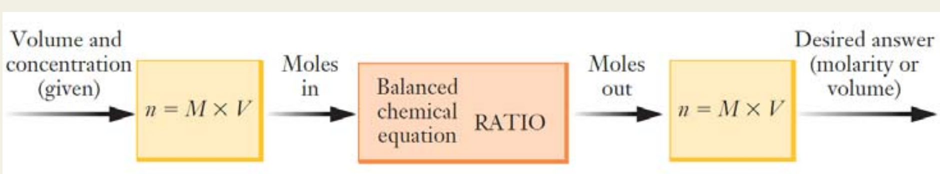
1) 69.7 g
2) 82.5 g
3) 165 g
4) 371 g

Answer: 165 g

Solution Stoichiometry



Important steps in a typical stoichiometry calculation:



- *n* = number of moles; *M* = mol/L; *V* = L

24

Example Problem

9) (a) If 750.0 mL of 0.806 M NaClO is mixed with excess ammonia, how many moles of hydrazine can be formed?

$$NaClO(aq) + 2NH_3(aq) \rightarrow N_2H_4(aq) + NaCl(aq) + H_2O(\ell)$$

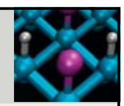
Number of moles of NaClO reacting,

$$n_{\mathrm{NaClO}} = M \times V = 0.806\,\mathrm{mol/L} \times 0.7500\ \mathrm{L} = 0.605\,\mathrm{mol\,NaClO}$$

By using the 1: 1 mole ratio from the balanced equation, number of moles of hydrazine,

$$0.605\,\mathrm{mol\,NaClO} \times \frac{1\,\mathrm{mol\,N_2H_4}}{1\,\mathrm{mol\,NaClO}} = 0.605\,\mathrm{mol\,N_2H_4}$$

Example Problem



9) (b) If the final volume of the resulting solution is 1.25 L, what will be the molarity of hydrazine?

$$M = \frac{n}{V} = \frac{0.605\,\mathrm{mol\,N_2H_2}}{1.25\ \mathrm{L}} = 0.484\ \mathrm{M\ N_2H_4}$$

Titration

- Titration: A common laboratory technique that requires understanding solution stoichiometry
  - Indicator: A dye used during titration that changes color to indicate when the reaction is complete

Titration

- A solution of one of the reactants (A) is added to a burette
- The burette is positioned above a flask containing the second reactant (B)
- Using the burette, A is added to the flask in a controlled manner
  - Volume is determined from initial and final burette readings
- The reaction is complete when the indicator changes color

Example Problem

10) If 24.75 mL of 0.503 M NaOH solution is used to titrate a 15.00-mL sample of sulfuric acid, H_2SO_4, what is the concentration of the acid?

$$\mathrm{H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(\ell)}$$

Number of moles NaOH,

$$0.02475\ \mathrm{L\ solution} \times \frac{0.503\,\mathrm{mol\,NaOH}}{1\ \mathrm{L\,solution}} = 0.0124\,\mathrm{mol\,NaOH}$$

Number of moles H_2SO_4,

$$0.0124\,\mathrm{mol\,NaOH} \times \frac{1\,\mathrm{mol\,H_2SO_4}}{2\,\mathrm{mol\,NaOH}} = 6.22 \times 10^{-3}\ \mathrm{mol\,H_2SO_4}$$

Concentration of H_2SO_4,

$$M = \frac{6.22 \times 10^{-3}\ \mathrm{mol\,H_2SO_4}}{0.01500\ \mathrm{L\,solution}} = 0.415\ \mathrm{M\ H_2SO_4}$$

11) In an acid-base neutralization, 23.74 mL of 0.500 M KOH reacts with 25.00 mL of H_2SO_4. What is the concentration of the acid?

a) 0.237 M
b) 0.475 M
c) 0.526 M
d) 0.950 M

Answer: a) 0.237 M