BCA METHOD

Focusing on Mole Ratios in Stoichiometry

Facilitators:

- Carmela Jones
- Anita White, PhD
- Deborah Scarano

*session based on
“The BCA Method in Stoichiometry”
by Larry Dukerich,
Modeling Instruction Program,
Arizona State University

Dimensional Analysis

- Algorithmic
  - grams A → moles A → moles B → grams B
- Disconnected from chemical equation
- Must start over for limiting reactant problems
- Is there another way?

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Lab Experience - context

- Reaction of sodium bicarbonate and sulfuric acid
- Split into pairs and follow the instructions on the lab sheet, collecting relevant data and conducting requested calculations.

Dimensional Analysis Method

- **Reaction of 2.00 g $NaHCO_3$ with 4 mL of 2.00 M H_2SO_4**

$$0.00800 \text{ mol } H_2SO_4 \times \frac{2 \text{ mol } CO_2}{1 \text{ mol } H_2SO_4} \times \frac{44\text{g } CO_2}{1 \text{ mol } CO_2} = 0.704 \text{ g } CO_2 \text{ theoretical yield}$$

- **Reaction of 2.00 g $NaHCO_3$ with 5 mL of 2.00 M H_2SO_4**

$$0.0100 \text{ mol } H_2SO_4 \times \frac{2 \text{ mol } CO_2}{1 \text{ mol } H_2SO_4} \times \frac{44\text{g } CO_2}{1 \text{ mol } CO_2} = 0.880 \text{ g } CO_2 \text{ theoretical yield}$$

- **Reaction of 2.00 g $NaHCO_3$ with 6 mL of 2.00 M H_2SO_4**

$$0.0238 \text{ mol } NaHCO_3 \times \frac{2 \text{ mol } CO_2}{2 \text{ mol } NaHCO_3} \times \frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2} = 1.05 \text{ g } CO_2 \text{ theoretical yield}$$

- **Reaction of 2.00 g $NaHCO_3$ with 7 mL of 2.00 M H_2SO_4**

$$0.0238 \text{ mol } NaHCO_3 \times \frac{2 \text{ mol } CO_2}{2 \text{ mol } NaHCO_3} \times \frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2} = 1.05 \text{ g } CO_2 \text{ theoretical yield}$$

- **Reaction of 2.00 g $NaHCO_3$ with 8 mL of 2.00 M H_2SO_4**

$$0.0238 \text{ mol } NaHCO_3 \times \frac{2 \text{ mol } CO_2}{2 \text{ mol } NaHCO_3} \times \frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2} = 1.05 \text{ g } CO_2 \text{ theoretical yield}$$

BCA Method

- Stresses *mole* relationships based on coefficients in balanced chemical equation
- Sets up equilibrium calculations later (ICE tables)
- Clearly shows limiting reactants

Emphasis on balanced equation

Step 1 – Balance the Equation

Balanced Equation: $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_20(l)$

BEFORE:						
CHANGE:						
AFTER:						

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Focus on the mole relationships

Step 2 – Fill in the Before Line (mol)

2.00 g sodium bicarbonate with 7 mL of 2.00 M sulfuric acid

Balanced Equation: $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_20(l)$

	$2NaHCO_3(s)$	$H_2SO_4(aq)$	$\rightarrow$	$Na_2SO_4(aq)$	$2CO_2(g)$	$2H_20(l)$
BEFORE:	**0.0238**	**0.01400**		**0**	**0**	**0**
CHANGE:						
AFTER:						

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Focus on the mole relationships

Step 3 – Ratios used for Change Line

Balanced Equation: $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_20(l)$

BEFORE:	0.0238	0.01400		0	0	0
CHANGE:	- 0.0238	- 0.01190		+ 0.01190	+ 0.0238	+ 0.0238
AFTER:						

Reactants are consumed (-), products are formed (+)

Change & After Line do NOT follow ratios from balanced equations

Step 4 – Complete the After Line

Balanced Equation: $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_20(l)$

BEFORE:	0.0238	0.01400		0	0	0
CHANGE:	- 0.0238	- 0.01190		+ 0.01190	+ 0.0238	+ 0.0238
AFTER:	0	0.00210		0.01190	0.0238	0.0238

Reactants are consumed (-), products are formed (+)

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Complete calculations outside table

- Theoretical yield of CO_2 in grams

$$0.0238 \text{ mol } CO_2 \times \frac{44 \text{ g } CO_2}{1 \text{ mol } CO_2} = 1.05 \text{ g } CO_2 \text{ theoretical yield}$$

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Moles go in the BCA table

- The balanced equation deals with *how many* NOT *how much*
- If given mass of reactants, convert to moles first, then use the table.
- If mass of products is desired, convert moles from table to mass.

What if the unit given is not moles?

- Mass → use molar mass to convert

$$2.00\ g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.008 g\ NaHCO_3} = 0.0238\ mol\ NaHCO_3$$

- Gas volume → use molar volume to convert

$$2.0\ L\ CO_2 \times \frac{1\ mol\ CO_2}{22.4\ L} = 0.0893\ mol\ CO_2$$

- Solution volume → use molarity to convert

$$0.00800\ L\ H_2SO_4 \times \frac{2.00\ mol\ H_2SO_4}{1.00\ L\ H_2SO_4} = 0.0160\ mol\ H_2SO_4$$

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Practice BCA Tables

- Solve Lab using a BCA table
- Solve additional worksheet on Limiting Reactants
- Solve additional worksheet on Percent Yield