LESSON MAKER PRO

Gas for the Bag

Calculate CO₂ for balloons and simulated air bags

HIGH SCHOOL · CHE.7.8

CHE.7.8 "Enrichment: Using gas stoichiometry, calculate the volume of carbon dioxide needed to inflate a balloon to occupy a specific volume. Use an engineering design process to design, construct, evaluate, and improve a simulated air bag.*"

NAME _____ **DATE** _____

FROM MOLES TO VOLUME

Use the balanced equation to find the moles of CO_2 produced. For this worksheet, each mole of gas occupies 24 L, and all gas is captured unless a problem says otherwise. Use these molar masses: $NaHCO_3$ = 84 g/mol and $CaCO_3$ = 100 g/mol.

WORKED EXAMPLE

In $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$, how much CO_2 does 5 mol of $NaHCO_3$ produce if HCl is in excess?

1. The equation shows a 1:1 mole ratio between $NaHCO_3$ and CO_2.
2. 5 mol $NaHCO_3$ produces 5 mol CO_2.
3. 5 mol × 24 L/mol = 120 L.

Answer: 120 L of CO_2

PRACTICE 6 problems

1 Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 3 mol of $NaHCO_3$ produce?

ANSWER _____

2 Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many moles of $NaHCO_3$ are needed to produce 96 L of CO_2?

ANSWER _____

3 Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 42 g of $NaHCO_3$ produce?

ANSWER _____

4 Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many grams of $NaHCO_3$ are needed to produce 18 L of CO_2?

ANSWER _____

5 Use $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. If $CaCO_3$ is in excess, how many liters of CO_2 will 2 mol of HCl produce?

ANSWER _____

6 Use $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 250 g of $CaCO_3$ produce?

ANSWER _____

APPLY IT Show your work

1 A film club wants a prop balloon to hold 16 L of CO_2. The club plans to use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$, with HCl in excess. If all the gas is captured, how many grams of $NaHCO_3$ are needed?

WORK SPACE

ANSWER _____

2 An engineering team needs a simulated air bag to hold 30 L of CO_2. Its design captures 75% of the gas produced by $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. With HCl in excess, how many grams of $NaHCO_3$ should the team use?

WORK SPACE

ANSWER _____

CHALLENGE One step up

A team tests a simulated air bag made with 168 g of $NaHCO_3$ and excess HCl. The reaction is $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$, but the bag captures only 75% of the gas. How many liters inflate the bag? The design goal is 48 L. Revise only the mass of $NaHCO_3$ to meet that goal if the capture rate stays the same. Explain your calculation.

WORK SPACE AND ANSWER

Gas for the Bag

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 3 mol of $NaHCO_3$ produce?	**72 L of CO_2**
2	Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many moles of $NaHCO_3$ are needed to produce 96 L of CO_2?	**4 mol of $NaHCO_3$**
3	Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 42 g of $NaHCO_3$ produce?	**12 L of CO_2**
4	Use $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$. If HCl is in excess, how many grams of $NaHCO_3$ are needed to produce 18 L of CO_2?	**63 g of $NaHCO_3$**
5	Use $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. If $CaCO_3$ is in excess, how many liters of CO_2 will 2 mol of HCl produce?	**24 L of CO_2**
6	Use $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. If HCl is in excess, how many liters of CO_2 will 250 g of $CaCO_3$ produce?	**60 L of CO_2**

PART 2 · APPLY IT

1. **56 g of $NaHCO_3$** 16 L ÷ 24 L/mol = 2/3 mol of CO_2. The 1:1 mole ratio requires 2/3 mol of $NaHCO_3$, or 56 g.
2. **140 g of $NaHCO_3$** The reaction must produce 30 L ÷ 3/4 = 40 L of CO_2. That is 40/24 mol of $NaHCO_3$, which has a mass of 140 g.

CHALLENGE

The test bag captures 36 L because 168 g produces 48 L and 75% of 48 L is 36 L. To capture 48 L, the reaction must produce 64 L, so the revised mass is 224 g of $NaHCO_3$.

Accept equivalent fraction-based calculations. All volumes use 24 L/mol; problems stating that a reactant is in excess assume the other reactant reacts completely.