

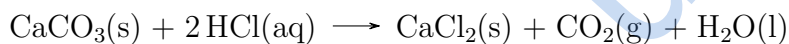
CHM 101 Holiday Assignment Stoichiometry Problems with Solutions

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Problem 1

Question: The following reaction was carried out:



If 10.0 grams of CaCO_3 was used, calculate:

- (a) The volume of CO_2 (at STP) produced from the complete reaction
- (b) The mass of CaCl_2 produced
- (c) How many moles of H_2O was produced

Solution:

Step 1: Calculate molar masses

$$M_{\text{CaCO}_3} = 40.0 + 12.0 + 3(16.0) = 100.0 \text{ g/mol}$$

$$M_{\text{CaCl}_2} = 40.0 + 2(35.5) = 111.0 \text{ g/mol}$$

$$M_{\text{CO}_2} = 12.0 + 2(16.0) = 44.0 \text{ g/mol}$$

$$M_{\text{H}_2\text{O}} = 2(1.0) + 16.0 = 18.0 \text{ g/mol}$$

Step 2: Calculate moles of CaCO_3

$$n_{\text{CaCO}_3} = \frac{10.0 \text{ g}}{100.0 \text{ g/mol}} = 0.100 \text{ mol}$$

Step 3: Use stoichiometry ratios (from balanced equation) From the balanced equation: $1 \text{ mol CaCO}_3 \rightarrow 1 \text{ mol CO}_2 \rightarrow 1 \text{ mol CaCl}_2 \rightarrow 1 \text{ mol H}_2\text{O}$

(a) Volume of CO_2 at STP:

$$n_{\text{CO}_2} = 0.100 \text{ mol}$$

At STP, 1 mol = 22.4 L:

$$V_{\text{CO}_2} = 0.100 \text{ mol} \times 22.4 \text{ L/mol} = 2.24 \text{ L}$$

(b) Mass of CaCl_2 :

$$n_{\text{CaCl}_2} = 0.100 \text{ mol}$$

$$m_{\text{CaCl}_2} = 0.100 \text{ mol} \times 111.0 \text{ g/mol} = 11.1 \text{ g}$$

(c) Moles of H_2O :

$$n_{\text{H}_2\text{O}} = 0.100 \text{ mol}$$

Answer 1:

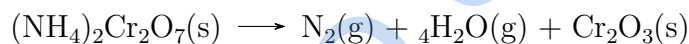
(a) 2.24 L of CO_2 at STP

(b) 11.1 g of CaCl_2

(c) 0.100 mol of H_2O

Problem 2

Question: 0.84 g of ammonium dichromate is decomposed according to the reaction:



Calculate the mass of Cr_2O_3 formed.

Solution:

Step 1: Calculate molar mass of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$

$$2 \times N : 2 \times 14.0 = 28.0$$

$$8 \times H : 8 \times 1.0 = 8.0$$

$$2 \times Cr : 2 \times 52.0 = 104.0$$

$$7 \times O : 7 \times 16.0 = 112.0$$

$$\text{Total} = 28.0 + 8.0 + 104.0 + 112.0 = 252.0 \text{ g/mol}$$

Step 2: Calculate moles of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$

$$n = \frac{0.84 \text{ g}}{252.0 \text{ g/mol}} = 0.00333 \text{ mol}$$

Step 3: Stoichiometry to find moles of Cr_2O_3 From the equation: 1 mol $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow$
1 mol Cr_2O_3

$$n_{\text{Cr}_2\text{O}_3} = 0.00333 \text{ mol}$$

Step 4: Calculate mass of Cr_2O_3

$$M_{\text{Cr}_2\text{O}_3} = 2(52.0) + 3(16.0) = 104.0 + 48.0 = 152.0 \text{ g/mol}$$

$$m_{\text{Cr}_2\text{O}_3} = 0.00333 \text{ mol} \times 152.0 \text{ g/mol} = 0.506 \text{ g}$$

Answer 2:

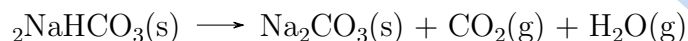
0.506 g of Cr_2O_3

Problem 3

Question: Calculate the mass of solid product obtained when 16.8 g of NaHCO_3 was strongly heated until there was no further change.

Solution:

Step 1: Write the decomposition reaction



Step 2: Calculate molar masses

$$M_{\text{NaHCO}_3} = 23.0 + 1.0 + 12.0 + 48.0 = 84.0 \text{ g/mol}$$

$$M_{\text{Na}_2\text{CO}_3} = 2(23.0) + 12.0 + 48.0 = 106.0 \text{ g/mol}$$

Step 3: Calculate moles of NaHCO_3

$$n_{\text{NaHCO}_3} = \frac{16.8 \text{ g}}{84.0 \text{ g/mol}} = 0.200 \text{ mol}$$

Step 4: Stoichiometry to find moles of Na_2CO_3 From the equation: 2 mol $\text{NaHCO}_3 \rightarrow$
1 mol Na_2CO_3

$$n_{\text{Na}_2\text{CO}_3} = \frac{0.200 \text{ mol}}{2} = 0.100 \text{ mol}$$

Step 5: Calculate mass of Na_2CO_3

$$m_{\text{Na}_2\text{CO}_3} = 0.100 \text{ mol} \times 106.0 \text{ g/mol} = 10.6 \text{ g}$$

Answer 3:

10.6 g of Na_2CO_3

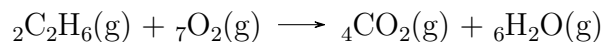
Problem 4

Question: In an experiment, 10 mL of ethane was burnt in 50 mL of oxygen.

- (a) Which gas was supplied in excess?
- (b) Calculate the volume of the excess gas remaining at the end of the reaction
- (c) Calculate the volume of CO_2 produced

Solution:

Step 1: Write the balanced combustion reaction



Step 2: Use volume ratios (at constant T and P) From the equation: 2 volumes $\text{C}_2\text{H}_6 \rightarrow$ 7 volumes $\text{O}_2 \rightarrow$ 4 volumes CO_2

Step 3: Calculate required O_2 for 10 mL C_2H_6

$$V_{\text{O}_2\text{required}} = 10 \text{ mL} \times \frac{7}{2} = 35 \text{ mL}$$

(a) **Identify excess gas:** Given $V_{\text{O}_2\text{supplied}} = 50 \text{ mL}$, required = 35 mL

O_2 is in excess

(b) **Calculate excess O_2 remaining:**

$$V_{\text{O}_2\text{excess}} = 50 \text{ mL} - 35 \text{ mL} = 15 \text{ mL}$$

(c) **Calculate volume of CO_2 produced:**

$$V_{\text{CO}_2} = 10 \text{ mL} \times \frac{4}{2} = 20 \text{ mL}$$

Answer 4:

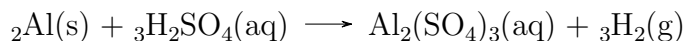
- (a) O_2 was in excess
- (b) 15 mL of O_2 remaining
- (c) 20 mL of CO_2 produced

Problem 5

Question: Aluminum metal reacts rapidly with aqueous sulfuric acid to produce aqueous aluminum sulfate and hydrogen gas. Determine the volume of hydrogen gas produced at STP when a 2.00 g piece of aluminum completely reacts.

Solution:

Step 1: Write the balanced reaction



Step 2: Calculate moles of Al

$$M_{\text{Al}} = 27.0 \text{ g/mol}$$

$$n_{\text{Al}} = \frac{2.00 \text{ g}}{27.0 \text{ g/mol}} = 0.0741 \text{ mol}$$

Step 3: Stoichiometry to find moles of H₂ From the equation: 2 mol Al → 3 mol H₂

$$n_{\text{H}_2} = 0.0741 \text{ mol} \times \frac{3}{2} = 0.111 \text{ mol}$$

Step 4: Calculate volume at STP

$$V_{\text{H}_2} = 0.111 \text{ mol} \times 22.4 \text{ L/mol} = 2.49 \text{ L}$$

Answer 5:

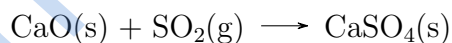
2.49 L of H₂ at STP

Problem 6

Question: Calcium oxide is used to remove sulfur dioxide generated in coal-burning power plants to produce CaSO₄. What mass of calcium oxide is required to react completely with 1.4 × 10³ L of sulfur dioxide?

Solution:

Step 1: Write the balanced reaction



Step 2: Calculate moles of SO₂ At STP: 1.4 × 10³ L = 1400 L

$$n_{\text{SO}_2} = \frac{1400 \text{ L}}{22.4 \text{ L/mol}} = 62.5 \text{ mol}$$

Step 3: Stoichiometry to find moles of CaO From the equation: 1 mol SO₂ → 1 mol CaO

$$n_{\text{CaO}} = 62.5 \text{ mol}$$

Step 4: Calculate mass of CaO

$$M_{\text{CaO}} = 40.0 + 16.0 = 56.0 \text{ g/mol}$$

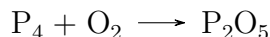
$$m_{\text{CaO}} = 62.5 \text{ mol} \times 56.0 \text{ g/mol} = 3500 \text{ g} = 3.50 \text{ kg}$$

Answer 6:

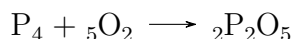
3.50 kg of CaO

Problem 7

Question: Balance the equation and calculate the volume of O₂ required to produce 75.0 g of P₂O₅ at STP.

**Solution:**

Step 1: Balance the equation



Step 2: Calculate molar mass of P₂O₅

$$M_{\text{P}_2\text{O}_5} = 2(31.0) + 5(16.0) = 62.0 + 80.0 = 142.0 \text{ g/mol}$$

Step 3: Calculate moles of P₂O₅

$$n_{\text{P}_2\text{O}_5} = \frac{75.0 \text{ g}}{142.0 \text{ g/mol}} = 0.528 \text{ mol}$$

Step 4: Stoichiometry to find moles of O₂ From the equation: 2 mol P₂O₅ → 5 mol O₂

$$n_{\text{O}_2} = 0.528 \text{ mol} \times \frac{5}{2} = 1.32 \text{ mol}$$

Step 5: Calculate volume at STP

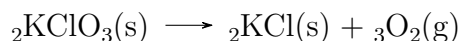
$$V_{\text{O}_2} = 1.32 \text{ mol} \times 22.4 \text{ L/mol} = 29.6 \text{ L}$$

Answer 7:

Balanced equation: $\text{P}_4 + 5\text{O}_2 \longrightarrow 2\text{P}_2\text{O}_5$
29.6 L of O₂ at STP

Problem 8

Question: Oxygen gas is sometimes prepared in labs by the thermal decomposition of potassium chlorate (KClO₃). The balanced chemical equation is:



If 5.150 grams decompose, what volume of O₂ would be obtained at STP?

Solution:

Step 1: Calculate molar mass of KClO_3

$$M_{\text{KClO}_3} = 39.0 + 35.5 + 3(16.0) = 39.0 + 35.5 + 48.0 = 122.5 \text{ g/mol}$$

Step 2: Calculate moles of KClO_3

$$n_{\text{KClO}_3} = \frac{5.150 \text{ g}}{122.5 \text{ g/mol}} = 0.04204 \text{ mol}$$

Step 3: Stoichiometry to find moles of O_2 From the equation: $2 \text{ mol KClO}_3 \rightarrow 3 \text{ mol O}_2$

$$n_{\text{O}_2} = 0.04204 \text{ mol} \times \frac{3}{2} = 0.06306 \text{ mol}$$

Step 4: Calculate volume at STP

$$V_{\text{O}_2} = 0.06306 \text{ mol} \times 22.4 \text{ L/mol} = 1.412 \text{ L}$$

Answer 8:

1.41 L of O_2 at STP