

GENERAL CHEMISTRY

STANDARD 9.9

EXAMPLE

- What mass of urea is produced from 9.0 liters of ammonia at a temperature of 23°C and a pressure of 14.0 atm?



- First, figure out the number of moles of ammonia using the Ideal Gas Law:

Step 1

$$\begin{aligned} n &= ? \\ V &= 9.0 \text{ L} = 0.0090 \text{ m}^3 \\ P &= 14.0 \text{ atm} = 1418200 \text{ Pa} \\ R &= 8.31 \text{ J/mol K} \\ T &= 23^\circ\text{C} = 296 \text{ K} \end{aligned}$$

Step 2

$$PV = nRT$$

Step 3

$$\frac{PV}{RT} = n$$

Step 4

$$\frac{1418200 \text{ Pa} \times 0.0090 \text{ m}^3}{8.31 \text{ J/mol K} \times 296 \text{ K}} = n$$

Step 5

$$n = 5.2 \text{ mol NH}_3$$

Now do stoichiometry to find the mass of urea produced:

$$\frac{5.2 \text{ mol NH}_3}{2 \text{ mol NH}_3} \times \frac{1 \text{ mol H}_2\text{NCONH}_2}{1 \text{ mol H}_2\text{NCONH}_2} \times 60.1 \text{ g H}_2\text{NCONH}_2 = 160 \text{ g H}_2\text{NCONH}_2$$

ANOTHER EXAMPLE

- What volume of oxygen gas is needed to completely react with 14.2 g of graphite at a temperature of 740°C and at a pressure of 550 kPa?



- First, use stoichiometry to find the number of moles of oxygen gas needed:

$$\frac{14.2 \text{ g C}}{12.01 \text{ g C}} \times \frac{1 \text{ mol C}}{1 \text{ mol C}} \times \frac{1 \text{ mol O}_2}{1 \text{ mol C}} = 1.2 \text{ mol O}_2$$

Step 1

$$\begin{aligned} n &= 1.2 \text{ mol O}_2 \\ V &= ? \\ P &= 550 \text{ kPa} = 550000 \text{ Pa} \\ R &= 8.31 \text{ J/mol K} \\ T &= 740^\circ\text{C} = 1013 \text{ K} \end{aligned}$$

Step 2

$$PV = nRT$$

Step 3

$$V = \frac{nRT}{P}$$

Step 4

$$V = \frac{1.2 \text{ mol} \times 8.31 \text{ J/mol K} \times 1013 \text{ K}}{550000 \text{ Pa}}$$

Step 5

$$V = 0.018 \text{ m}^3 = 18 \text{ L}$$

TRY IT YOURSELF

- Potassium metal reacts explosively with water by producing hydrogen gas and leaving potassium hydroxide in solution. What volume of hydrogen gas is produced when a 0.50 g piece of potassium is added to water at 26.5°C and 1.014 atm pressure?
- In the combustion of propane gas, C_3H_8 , what volume of carbon dioxide gas is produced when a 9.1 kg tank of propane is completely consumed at 26.0°C and 1.0 atm of pressure?
- When strongly heated, $CaCO_3$ decomposes into carbon dioxide gas and calcium oxide. What mass of calcium carbonate is needed to produce 800.0 mL of carbon dioxide at 19.0°C and 0.966 atm?

TRY IT YOURSELF SOLUTIONS

- Potassium metal reacts explosively with water by producing hydrogen gas and leaving potassium hydroxide in solution. What volume of hydrogen gas is produced when a 0.50 g piece of potassium is added to water at 26.5°C and 1.014 atm pressure?

$$V = 0.155 \text{ L} = 155 \text{ mL}$$

- In the combustion of propane gas, C_3H_8 , what volume of carbon dioxide gas is produced when a 9.1 kg tank of propane is completely consumed at 26.0°C and 1.0 atm of pressure?

$$V = 15\,000 \text{ L}$$

- When strongly heated, CaCO_3 decomposes into carbon dioxide gas and calcium oxide. What mass of calcium carbonate is needed to produce 800.0 mL of carbon dioxide at 19.0°C and 0.966 atm?

$$m = 3.23 \text{ g CaCO}_3$$