Stoichiometry & Solutions

Section 7.3 Review

Applying Inquiry/ Communication Skills

1. Aluminum reacts with hydrochloric acid according to the equation:

$$2\ Al(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

Calculate the volume of 1.50 mol·L^{-1} hydrochloric acid that is required for 5.40 g aluminum to react completely.

2. Zinc metal reacts with hydrochloric acid according to the equation:

$$Zn(s) + 2\ HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$

A piece of zinc metal requires 75.0 mL of 3.00 mol·L^{-1} hydrochloric acid for a complete reaction. Determine the mass of the zinc metal used.

3. Calculate the volume of 0.110 mol·L^{-1} sodium sulfate required to precipitate the maximum mass of barium sulfate from 60.0 mL of 0.145 mol·L^{-1} barium chloride solution. The balanced equation is:

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\ NaCl(aq)$$

4. Copper reacts with concentrated nitric acid according to the equation following:

$$3\ Cu(s) + 8\ HNO_3(aq) \rightarrow 3\ Cu(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(l)$$

Calculate the volume of nitric acid (16.0 mol·L^{-1}) required for a complete reaction if 25.0 g copper metal are used.

Making Connections

6. About 20 000 t of titanium dioxide are produced each year in Quebec by the sulfate process. Calculate the mass of pure iron(II) titanate that must be mined to obtain this mass of product and the volume of concentrated sulfuric acid (18 mol·L^{-1}) that the plant has to purchase each year. Determine the environmental consequences of extracting titanium using the sulfate process.

Practice

Understanding Concepts

1. Ammonium sulfate is a "high-nitrogen" fertilizer. It is manufactured by reacting sulfuric acid with ammonia. In a laboratory study of this process, 50.0 mL of sulfuric acid reacts with 24.4 mL of a 2.20 mol/L ammonia solution to yield the product ammonium sulfate in solution. From this evidence, calculate the molar concentration of the sulfuric acid at this stage in the process.

2. Slaked lime is sometimes used in water treatment plants to clarify water for residential use. The lime is added to an aluminum sulfate solution in the water. Fine particles in the water stick to the floc precipitate produced, and settle out with it. Calculate the volume of 0.0250 mol/L calcium hydroxide solution that can be completely reacted with 25.0 mL of 0.125 mol/L aluminum sulfate solution.

3. In designing a solution stoichiometry experiment for her class to perform, a chemistry teacher wants 75.0 mL of 0.200 mol/L iron(III) chloride solution to react completely with an excess of 0.250 mol/L sodium carbonate solution.
   (a) What is the *minimum* volume of this sodium carbonate solution needed?
   (b) What would be a *reasonable* volume of this sodium carbonate solution to use in this experiment? Provide your reasoning.

Answers

1. 0.537 mol/L
2. 375 mL
3. (a) 90.0 mL
   (b) 100 mL

Stoichiometry & Solutions Assignment

1. $2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$

5.40 g — 1.5 mol/L

$M_{Al} = 26.98$ g/mol — V = ?

n = 0.2 mol

$\frac{0.2}{2} \times 6 = 0.6$ mol HCl

$V = \frac{n}{C}$

$= \frac{.6}{1.5}$

$V = 0.4$ L

$n = C \times V$

$V = \frac{n}{C}$

(3)

2. $Zn + 2HCl \rightarrow H_2 + ZnCl_2$

? mass — 75 mL = .075 L — 3 mol/L

$n = C \times V$

$= 0.225$

$\frac{.225}{2} = 0.1125$ mol

$\times 65.39$ g/mol

7.36 g Zn

(3)

3. $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$

60 mL = .06 L — 0.11 mol/L

0.145 mol/L — 1:1 ∴ 0.0087 mol

$n = C \times V$

$= 0.0087$ mol

$V = \frac{n}{C}$

$= \frac{.0087}{0.11}$

$= 0.079$ L

$= 79$ mL

(3)

4. $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

25 g
÷ 63.55 g/mol
= 0.3934 mol

V = ?
16 mol/L

$\frac{0.3934 \text{ mol}}{3} \times 8 = 1.049 \text{ mol}$ ✓

$V = \frac{n}{c}$ ✓

$= \frac{1.049}{16}$ ✓

$= 0.0656 \text{ L}$

$= 65.6 \text{ mL}$ ✓

(3)

6. BONUS

$Fe(TiO_3) + H_2SO_4 \rightarrow TiO_2 + H_2O + FeSO_4$

? g

V ?
C = 18 mol/L

20000 t
= 20000000000
2×10^{10} g

$\frac{2 \times 10^{10} \text{ g}}{79.87 \text{ g/mol}} = 250406911 \text{ mol}$
2.5×10^8 mol

18

TiO_2 47.87
32.00
79.87 g/mol

+