12.3 Limiting Reagent and Percent Yield

1 FOCUS

Objectives

12.3.1 Identify the limiting reagent in a reaction.

12.3.2 Calculate theoretical yield, percent yield, and the amount of excess reagent that remains unreacted given appropriate information.

Dec 13-3:29 PM

p370

SAMPLE PROBLEM 12.7

Determining the Limiting Reagent in a Reaction

Copper reacts with sulfur to form copper(I) sulfide according to the following balanced equation.

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

What is the limiting reagent when 80.0 g Cu reacts with 25.0 g S?

1.26 0.78

$2Cu(s) + S(s) \rightarrow Cu_2S(s)$

80g 25g

limiting reagent

limiting reagent is Copper

$\frac{1\,mol_{Cu}}{63.55} = \frac{n}{80_g}$

1.26moles

or ÷2

0.63moles

S

$\frac{1\,mol}{32.065} = \frac{n\,moles}{25_g}$

0.78moles

X2

1.55moles

Apr 12-9:58 AM

p370

SAMPLE PROBLEM 12.7

Determining the Limiting Reagent in a Reaction

Copper reacts with sulfur to form copper(I) sulfide according to the following balanced equation.

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

What is the limiting reagent when 80.0 g Cu reacts with 25.0 g S?

$2\,Cu(s) + S(s) \longrightarrow Cu_2S(s)$

80.0g 25g

$\frac{1\,mol\,(Cu)}{63.55g} = \frac{n\,mol}{80g}$ $\frac{1\,mol\,(S)}{32.07} = \frac{n\,mol}{25g}$

$n = 1.26\,moles$ $n = 0.78\,moles$

↑ limiting Reagent $\times 2$

$1.56\,moles\,of\,Cu$

$2\,Cu(s) + S(s) \longrightarrow Cu_2S(s)$

or

1.26 mole of Cu

÷2

0.63 moles of S are need for a balanced chemical reaction

Apr 12-9:58 AM

25 The equation for the complete combustion of ethene (C_2H_4) is

p370

$$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g)$$

If 2.70 mol C_2H_4 is reacted with 6.30 mol O_2, identify the limiting reagent.

limiting reagent

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

2.70 mole 6.30mol

$\times 3$

8.10

Apr 12-9:58 AM

p 370

25. The equation for the complete combustion of ethene (C_2H_4) is

$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g)$

If 2.70 mol C_2H_4 is reacted with 6.30 mol O_2, identify the limiting reagent.

across

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

ethene

2.70 moles × 3 = 8.1 moles

6.30 moles

or 6.3 ÷ 3 = 2.1

Limiting reagent

Apr 12-9:58 AM

p 370

26. Hydrogen gas can be produced by the reaction of magnesium metal with hydrochloric acid.

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

Identify the limiting reagent when 6.00 g HCl reacts with 5.00 g Mg.

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

5.00 g Mg = 0.21 moles

6.00 g HCl = 0.16 moles

$\frac{1 \text{ mol}}{24.31} = \frac{n \text{ mol}}{5.00 \text{ g}}$

$n = 0.21$

$\frac{1 \text{ mol}}{36.46 \text{ g}} = \frac{n \text{ mol}}{6.00 \text{ g}}$

$n = 0.16$ moles

$\frac{0.16}{2} = 0.08$ moles

0.21 × 2 = 0.42

limiting reagent HCl

Apr 12-9:58 AM

26. Hydrogen gas can be produced by the reaction of magnesium metal with hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

Identify the limiting reagent when 6.00 g HCl reacts with 5.00 g Mg.

Apr 12-9:58 AM

p 370

26. Hydrogen gas can be produced by the reaction of magnesium metal with hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

Identify the limiting reagent when 6.00 g HCl reacts with 5.00 g Mg.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

Apr 12-9:58 AM

P371

SAMPLE PROBLEM 12.8

Using a Limiting Reagent to Find the Quantity of a Product

What is the maximum number of grams of Cu_2S that can be formed when 80.0 g Cu reacts with 25.0 g S?

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

$\frac{1}{2}(2Cu + S \rightarrow Cu_2S)$

80g 25g ?g

1.26 moles 0.78 moles

Copper is the limiting reagent

Cu_2S S ~~Cu~~

Reaction is Done

$1.26(Cu + \frac{1}{2}S \rightarrow \frac{1}{2}Cu_2S)$

$1.26Cu + 0.635 \rightarrow 0.63Cu_2S$

$\frac{1\ mole\ Cu_2S}{159.1g} = \frac{0.63}{X\ g\ Cu_2S}$ $X = 100.23g$

Apr 12-9:59 AM

P371

SAMPLE PROBLEM 12.8

Using a Limiting Reagent to Find the Quantity of a Product

What is the maximum number of grams of Cu_2S that can be formed when 80.0 g Cu reacts with 25.0 g S?

$$2Cu(s) + S(s) \longrightarrow Cu_2S(s)$$

$X\ \frac{1}{2}$ ($2Cu(s) + S(s) \longrightarrow Cu_2S(s)$)

80g 25g

1.26 mol 0.78 mol.

$1.26(Cu(s) + \frac{1}{2}S(s) \rightarrow \frac{1}{2}Cu_2S(s))$

$1.26Cu + 0.635(s) \rightarrow 0.63Cu_2S$

$\frac{1\ mol\ Cu_2S}{157.16g} = \frac{0.63mol}{X}$ $X = 99.01g$

Apr 12-9:59 AM

P371

27. The equation below shows the incomplete combustion of ethene.

$$C_2H_4(g) + 2O_2(g) \longrightarrow 2CO(g) + 2H_2O(g)$$

If 2.70 mol C_2H_4 is reacted with 6.30 mol O_2,

a. identify the limiting reagent.

b. calculate the moles of water produced.

28. The heat from an acetylene torch is produced by burning acetylene (C_2H_2) in oxygen.

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

How many grams of water can be produced by the reaction of 2.40 mol C_2H_2 with 7.4 mol O_2?

Apr 12-9:59 AM

28. The heat from an acetylene torch is produced by burning acetylene (C_2H_2) in oxygen.

$$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$$

How many grams of water can be produced by the reaction of 2.40 mol C_2H_2 with 7.4 mol O_2?

Apr 12-9:59 AM

P374

SAMPLE PROBLEM 12.9

Calculating the Theoretical Yield of a Reaction

Calcium carbonate, which is found in seashells, is decomposed by heating. The balanced equation for this reaction is:

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$ (Δ ← Heat)

What is the theoretical yield of CaO if 24.8 g $CaCO_3$ is heated?

0.248 ($CaCO_3 \rightarrow CaO + CO_2$)

24.8g ↑ ↑ ?g

$$\frac{1\,mol\ CaCO_3}{100.1g} = \frac{n\,mol}{24.8g} \qquad n = 0.248$$

$$\frac{1\,mol\ CaO}{56.1g} = \frac{0.248}{x\,g} \qquad x = 13.91g$$

Apr 12-10:00 AM

29. When 84.8 g of iron(III) oxide reacts with an excess of carbon monoxide, iron is produced

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$$

What is the theoretical yield of this reaction?

2x0.53=1.06

0.53 ($Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$)

84.8g ↑ excess ↑ ?g

$$\frac{1\,mol\ Fe_2O_3}{159.68g} = \frac{n\,mol}{84.8g} \qquad n = 0.53$$

$$\frac{1\,mol\ Fe}{55.85g} = \frac{1.06\,mol}{x} \qquad x = 59.32g$$

Apr 12-10:00 AM

30. When 5.00 g of copper reacts with excess silver nitrate, silver metal and copper (II) nitrate are produced. What is the theoretical yield of silver in this reaction?

Ag^+ NO_3^-

$2 \times 0.079 = 0.16$

0.079

$Cu(s) + 2AgNO_3 \rightarrow 2Ag(s) + Cu(NO_3)_2$

5g excess g?

$\frac{1 mol\ Cu}{63.55} = \frac{n}{5g}$

$n = 0.079$

$\frac{1 mol\ Ag}{107.87g} = \frac{0.16}{x g}$

$x = 17.26g$

Apr 12-10:00 AM

Limiting Reagent Worksheet

Using your knowledge of stoichiometry and limiting reagents, answer the following questions:

1) Write the balanced equation for the reaction of lead (II) nitrate with sodium iodide to form sodium nitrate and lead (II) iodide:

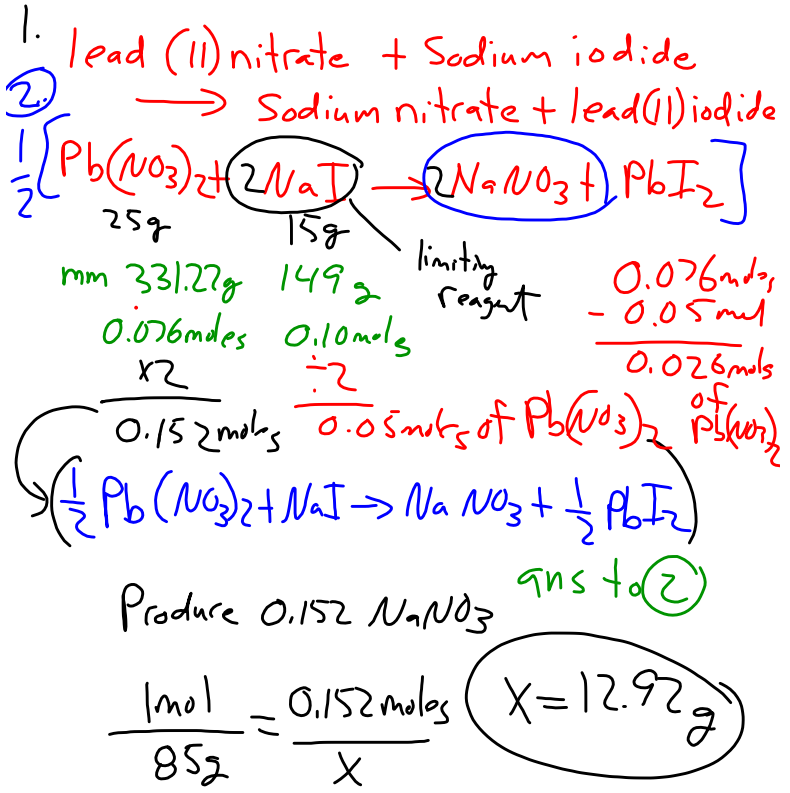
2) If I start with 25.0 grams of lead (II) nitrate and 15.0 grams of sodium iodide, how many grams of sodium nitrate can be formed?

3) What is the limiting reagent in the reaction described in problem 2?

4) How much of the nonlimiting reagent will be left over from the reaction in problem #2?

Jun 13-6:58 PM

Limiting Reagent Worksheet



Jun 10-2:30 PM