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Limiting Reactant and Percent Yield Practice Problems

Limiting Reactant Problems: Write and balance each equation. Determine which reactant is the limiting reactant. Then answer the question specific to each problem.

Steps to identifying the limiting reactant:
1. Write and balance the equation.
2. Convert g to mol to mol of one product for all the reactants.
3. The limiting reactant is the reactant that produces the smallest the quantity of product.
4. Solve the rest of the problem and answer the question that is posed.

★ 1. 3.45 moles of nitrogen gas (N2) react with 4.85 moles of hydrogen gas (H2) to form ammonia (NH3). What is the limiting reactant? How many moles of ammonia will form?

$N_2 + 3H_2 \rightarrow 2NH_3$

$3.45\ mol\ N_2 \left| \frac{2\ mol\ NH_3}{1\ mol\ N_2} \right. = 6.9\ mol\ NH_3$

H_2 is limiting!

$4.85\ mol\ H_2 \left| \frac{2\ mol\ NH_3}{3\ mol\ H_2} \right. = 3.2\ mol\ NH_3$

2. A welder has 20.0 moles of acetylene gas (C2H2) and 10.0 moles of oxygen gas (O2). They combine to form water and carbon dioxide. Identify the limiting reactant. How many moles of carbon dioxide gas (CO2) will form?

$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

O_2 is limiting!

$20.0\ mol\ C_2H_2 \left| \frac{4\ mol\ CO_2}{2\ mol\ C_2H_2} \right. = 40\ mol\ CO_2$

$10.0\ mol\ O_2 \left| \frac{4\ mol\ CO_2}{5\ mol\ O_2} \right. = 8\ mol\ CO_2$

★ 3. A student places 2.36 moles of acetic acid (CH3CO2H) and 3.89 moles of sodium hydroxide (NaOH) in a beaker of water. They react to form sodium acetate (NaCH3CO2) and water. How many moles of water will form?

$CH_3COOH + NaOH \rightarrow NaCH_3CO_2 + H_2O$

$2.36\ mol\ CH_3COOH \left| \frac{1\ mol\ H_2O}{1\ mol\ CH_3COOH} \right. = 2.36\ mol\ H_2O$

$3.89\ mol\ NaOH \left| \frac{1\ mol\ H_2O}{1\ mol\ NaOH} \right. = 3.89\ mol\ NaOH$

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4. 0.300 moles of bromine gas (Br2) and 0.500 moles of chlorine gas (Cl2) react to form tribromochlorine (Br3Cl). How many moles of this product will form?

$3Br_2 + Cl_2 \rightarrow 2Br_3Cl$

$$0.300 \text{ mol } Br_2 \left| \frac{2 \text{ mol } Br_3Cl}{3 \text{ mol } Br_2} \right. = \boxed{0.2 \text{ mol } Br_3Cl}$$

$$0.500 \text{ mol } Cl_2 \left| \frac{2 \text{ mol } Br_3Cl}{1 \text{ mol } Cl_2} \right. = 1 \text{ mol } Br_3Cl$$

★ 5. 100.0 grams of sodium sulfate reacts with 50.00 grams of barium nitrate to form sodium nitrate and barium sulfate. How many grams of barium sulfate will form?

$Na_2SO_4 + Ba(NO_3)_2 \rightarrow 2NaNO_3 + BaSO_4$

$$100 \text{ g } Na_2SO_4 \left| \frac{1 \text{ mol } Na_2SO_4}{142 \text{ g } Na_2SO_4} \right| \frac{1 \text{ mol } BaSO_4}{1 \text{ mol } Na_2SO_4} = 0.70 \text{ mol } BaSO_4$$

$$50 \text{ g } Ba(NO_3)_2 \left| \frac{1 \text{ mol } Ba(NO_3)_2}{261.32 \text{ g } Ba(NO_3)_2} \right| \frac{1 \text{ mol } BaSO_4}{1 \text{ mol } Ba(NO_3)_2} = 0.19 \text{ mol } BaSO_4 \left| \frac{233.3}{1 \text{ mol}} \right.$$

44.4 g $BaSO_4$

6. 15.5 grams of hydrogen gas reacts with 30.0 grams of oxygen gas to form water vapor. How many grams of water vapor will form?

$2H_2 + O_2 \rightarrow 2H_2O$

$$15.5 \text{ g } H_2 \left| \frac{1 \text{ mol } H_2}{2 \text{ g}} \right| \frac{2 \text{ mol } H_2O}{2 \text{ mol } H_2} = 7.75 \text{ mol } H_2O$$

$$30.0 \text{ g } O_2 \left| \frac{1 \text{ mol } O_2}{32 \text{ g } O_2} \right| \frac{2 \text{ mol } H_2O}{1 \text{ mol } O_2} = 1.88 \text{ mol } H_2O \left| \frac{18 \text{ g } H_2O}{1 \text{ mol } H_2O} \right. = \boxed{33.84 \text{ g } H_2O}$$

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★ 7. 10.0 g of acetic acid (CH3CO2H) reacts with 10.0 g of lead (II) hydroxide to form water and lead (II) acetate (Pb(CH3CO2)2) and water. Which reactant is in excess? How many grams of it will remain after the reaction goes to completion? How many grams of lead (II) acetate will form?

$$2CH_3COOH + Pb(OH)_2 \rightarrow 2H_2O + Pb(CH_3COO)_2$$

$$10.0\text{ g } CH_3COOH \left| \frac{1\text{ mol } CH_3COOH}{60\text{ g } CH_3COOH} \right| \frac{1\text{ mol } Pb(CH_3COO)_2}{2\text{ mol } CH_3COOH} = 0.083\text{ mol}$$

CH_3COOH is in excess

$$10.0\text{ g } Pb(OH)_2 \left| \frac{1\text{ mol } Pb(OH)_2}{243.2\text{ g } Pb(OH)_2} \right| \frac{1\text{ mol } Pb(CH_3COO)_2}{1\text{ mol } Pb(OH)_2} = 0.041\text{ mol} \left| \frac{325.288\text{ g } Pb(CH_3COO)_2}{1\text{ mol } Pb(CH_3COO)_2} \right.$$

$$0.041\text{ mol } Pb(CH_3COO)_2 \left| \frac{2\text{ mol } CH_3COOH}{1\text{ mol } Pb(CH_3COO)_2} \right| \frac{60.05\text{ g } CH_3COOH}{1\text{ mol } CH_3COOH} =$$

4.92 g used

13.38 g $Pb(CH_3COO)_2$ form

10 g − 4.92 g = 5.08 g CH_3COOH in excess

8. 25.3 g of magnesium reacts with 44.3 g of copper (II) nitrate to form copper and magnesium nitrate. What mass of copper will form? What mass of reactants will remain unreacted?

$$Mg + Cu(NO_3)_2 \rightarrow Cu + Mg(NO_3)_2$$

$$25.3\text{ g Mg} \left| \frac{1\text{ mol Mg}}{24.31\text{ g Mg}} \right| \frac{1\text{ mol Cu}}{1\text{ mol Mg}} = 1.04\text{ mol Cu}$$

$$0.24\text{ mol Cu} \left| \frac{1\text{ mol Mg}}{1\text{ mol Cu}} \right| \frac{24.31\text{ g Mg}}{1\text{ mol Mg}} =$$

5.83 g Mg used

$$44.3\text{ g } Cu(NO_3)_2 \left| \frac{1\text{ mol } Cu(NO_3)_2}{187.55\text{ g } Cu(NO_3)_2} \right| \frac{1\text{ mol Cu}}{1\text{ mol } Cu(NO_3)_2} = 0.24\text{ mol Cu} \left| \frac{63.55\text{ g Cu}}{1\text{ mol Cu}} \right. = 15.25\text{ g Cu}$$

25 g − 5.83 g = 19.47 g Mg in excess

Percent Yield Problems: Write and balance each equation and determine the percent yield.

★ 9. Determine the % yield when 7.80 grams of benzene (C6H6) burns in oxygen gas (O2) to form 3.00 grams of CO2 gas and water vapor.

$$2C_6H_6 + 15O_2 \rightarrow 6H_2O + 12CO_2$$

$$7.80\text{ g } C_6H_6 \left| \frac{1\text{ mol } C_6H_6}{78\text{ g } C_6H_6} \right| \frac{12\text{ mol } CO_2}{2\text{ mol } C_6H_6} \left| \frac{44\text{ g } CO_2}{1\text{ mol } CO_2} \right. = 26.4\text{ g } CO_2$$

$$\frac{3.00\text{ g } CO_2}{26.4\text{ g } CO_2} \times 100\% = 11.36\%$$

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10. What is the % yield when 140.0 grams of ethylene gas (C2H4) reacts with excess Chlorine gas (Cl2) to form 280.0 grams of 1,2-Dichloro Ethane (C2H4Cl2) according to the equation: C2H4 + Cl2 → C2H4Cl2?

$$\frac{140.0\text{ g } C_2H_4}{} \left| \frac{1\text{ mol } C_2H_4}{28\text{ g } C_2H_4} \right| \frac{1\text{ mol } C_2H_4Cl_2}{1\text{ mol } C_2H_4} \left| \frac{99\text{ g } C_2H_4Cl_2}{1\text{ mol } C_2H_4Cl_2} \right. = 495\text{ g } C_2H_4Cl_2$$

$$\frac{280.0\text{ g}}{495\text{ g}} \times 100 = \boxed{56.6\%}$$

11. A process to produce aluminum from aluminum oxide has an 85% yield. How much aluminum will be produced from a reacting 700.0 kg of aluminum oxide to produce Al? (assume that the reaction is Al2O3 + H2 → Al + H2O)

$$Al_2O_3 + 3H_2 \rightarrow 2Al + 3H_2O$$

$$\frac{700\text{ kg } Al_2O_3}{} \left| \frac{1000\text{ g}}{1\text{ kg}} \right| \frac{1\text{ mol } Al_2O_3}{101.96\text{ g } Al_2O_3} \left| \frac{2\text{ mol Al}}{1\text{ mol } Al_2O_3} \right| \frac{26.98\text{ g Al}}{1\text{ mol Al}} = $$

$$85\% = \frac{x\text{ kg Al}}{370.46\text{ kg Al}} \times 100$$

$$\boxed{314.89\text{ kg Al}}$$