Stoichiometry 5

① How many atoms of magnesium will react with 4.5 g of nitrogen to make magnesium nitride (Mg_3N_2)?

24.30 g/mol 28.02 g/mol

$3\,Mg_{(s)} + N_{2(g)} \rightarrow Mg_3N_{2(s)}$

? atoms 4.5 g N_2

$$\frac{4.5\text{ g } N_2}{} \left|\frac{1\text{ mol } N_2}{28.02\text{ g } N_2}\right|\frac{3\text{ mol Mg}}{1\text{ mol } N_2}\left|\frac{6.022\times10^{23}\text{ Mg atoms}}{1\text{ mol Mg}}\right.$$

$$= 2.9\times10^{23}\text{ atoms}$$

2. Consider the reaction of nitrogen gas with hydrogen gas with to make ammonia gas:
$N_2 + 3\,H_2 \rightarrow 2\,NH_3$

A) How many moles of hydrogen are required to fully react with 1.98×10^{24} molecules of nitrogen?
B) What is the theoretical yield of ammonia produced in this reaction?

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$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

1.98×10^{24} molec

mol → mol

$$\frac{1.98\times10^{24}\text{ molec } N_2}{} \left|\frac{1\text{ mol } N_2}{6.022\times10^{23}\text{ molec } N_2}\right|\frac{3\text{ mol } H_2}{1\text{ mol } N_2} = 9.86\text{ mol } H_2$$

$$\frac{1.98\times10^{24}\text{ molec } N_2}{} \left|\frac{1\text{ mol } N_2}{6.022\times10^{23}\text{ molec } N_2}\right|\frac{2\text{ mol } NH_3}{1\text{ mol } N_2}\left|\frac{17.04\text{ g } NH_3}{1\text{ mol } NH_3}\right.$$

$$= 112\text{ g } NH_3$$

(3) Consider the formation of H_20: $2\ H_2 + O_2 \rightarrow 2\ H_2O$. How many grams of water could be produced from the reaction of 56.2 L of oxygen gas with excess hydrogen at STP?

18.02 g/mol

$$2\ H_2 + O_2 \rightarrow 2H_2O$$

56.2 L

$$\frac{56.2\text{ L}}{22.4\text{ L}} \left| \frac{1\text{ mol } O_2}{1\text{ mol } O_2} \right| \frac{2\text{ mol } H_2O}{1\text{ mol } H_2O} \left| \frac{18.02\text{ g } H_2O}{1\text{ mol } H_2O} \right| = 90.4\text{ g } H_2O$$

4. Iron metal reacts with oxygen to make iron (III) oxide by the following reaction: $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$. If 72.0 g of iron and 67.0 g of oxygen are present initially,
   A) What is the limiting reagent?
   B) What mass of iron(III) oxide is produced?
   C) What mass of the excess reagent remains at the end of the reaction?

$$4\ Fe + 3O_2 \rightarrow 2\ Fe_2O_3$$

72.0 g 67.0 g

A) $$\frac{72.0\text{ g Fe}}{55.85\text{ g Fe}} \left| \frac{1\text{ mol Fe}}{4\text{ mol Fe}} \right| \frac{2\text{ mol } Fe_2O_3}{} = 0.6446\text{ mol } Fe_2O_3$$

$$\frac{67.0\text{ g } O_2}{32.0\text{ g}} \left| \frac{1\text{ mol } O_2}{3\text{ mol } O_2} \right| \frac{2\text{ mol } Fe_2O_3}{} = 1.396\text{ mol } Fe_2O_3$$

Fe is LR

B) $$\frac{0.6446\text{ mol } Fe_2O_3}{1\text{ mol } Fe_2O_3} \left| \frac{159.7\text{ g } Fe_2O_3}{} \right| = 103\text{ g}$$

c) $$\frac{72.0\text{ g Fe}}{55.85\text{ g Fe}} \left| \frac{1\text{ mol Fe}}{4\text{ mol Fe}} \right| \frac{3\text{ mol } O_2}{1\text{ mol } O_2} \left| \frac{32.0\text{ g } O_2}{} \right| = 30.9\text{ g } O_2 \text{ used}$$

$$67.0\text{ g } O_2 \text{ start} - 30.9\text{ g } O_2 \text{ used} = 36.1\text{ g } O_2 \text{ remain}$$

(5) Given the reaction: $3\ Ba(NO_3)_2 + 2\ AlCl_3 \rightarrow 2\ Al(NO_3)_3 + 3\ BaCl_2$. If you wish to make 1.45 kg of $BaCl_2$, what volume of a 3.552 M solution of $AlCl_3$ would be required?

$$3\ Ba(NO_3)_2 + 2\ AlCl_3 \rightarrow 3\ BaCl_2 + 2Al(NO_3)_3$$

$3.552\ \frac{mol}{L}$ $\qquad$ $1.45\ kg = 1450\ g$

$$1450\ g\ BaCl_2 \left| \frac{1\ mol\ BaCl_2}{208.23\ g\ BaCl_2} \right| \frac{2\ mol\ AlCl_3}{3\ mol\ BaCl_2} \left| \frac{1\ L\ AlCl_3}{3.552\ mol\ AlCl_3} \right.$$

$$= 1.31\ L\ AlCl_3$$

(6) Lead (II) nitrate reacts with ammonium phosphate to produce a precipitate. If 455 mL of a 2.55 M lead (II) nitrate solution is reacted with excess ammonium phosphate, what mass of the precipitate will be formed?

$$3Pb(NO_3)_2 + 2(NH_4)_3PO_4 \rightarrow Pb_3(PO_4)_{2(s)} + 6NH_4NO_3$$

$455\ mL$

$2.55\ \frac{mol}{L}$ $Pb(NO_3)_2$

$$0.455\ L \left| \frac{2.55\ mol\ Pb(NO_3)_2}{1\ L\ Pb(NO_3)_2} \right| \frac{1\ mol\ Pb_3(PO_4)_2}{3\ mol\ Pb(NO_3)_2} \left| \frac{811.54\ g\ Pb_3(PO_4)_2}{1\ mol\ Pb_3(PO_4)_2} \right.$$

$$= 313\ g\ Pb_3(PO_4)_2$$

(7) Consider the reaction of Mg with HCl. If a long strip of Mg with a volume of 2.85 cm^3 were allowed to react with excess HCl,

A) How many moles of $MgCl_2$ would be produced?

B) What would be the molarity of $MgCl_2$ if the total volume of the solution were 250 mL?

1.74 g/cm3

24.30 g/mol

$$Mg + 2HCl \longrightarrow MgCl_2 + H_{2(g)}$$

$$2.85\ cm^3\ Mg \left| \frac{1.74\ g\ Mg}{1\ cm^3\ Mg} \right| \frac{1\ mol\ Mg}{24.30\ g\ Mg} \left| \frac{1\ mol\ MgCl_2}{1\ mol\ Mg} \right| = 0.204\ mol\ MgCl_2$$

$$M = \frac{mol}{L} = \frac{0.204\ mol}{0.250\ L} = 0.816\ M$$

(8) A sample of sandstone contains silica (SiO_2) and calcite ($CaCO_3$). When the sandstone is heated the $CaCO_3$ decomposes by the reaction: $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$. What is the percentage of silica in the sandstone if heating 18.7 mg of the rock yields 3.95 mg CO_2?

$$3.95\ mg\ CO_2 \left| \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} \right| \frac{1\ mol\ CaCO_3}{1\ mol\ CO_2} \left| \frac{100.09\ g\ CaCO_3}{1\ mol\ CaCO_3} \right| =$$

$$8.98\ mg\ CaCO_3$$

$$\frac{8.98\ mg\ CaCO_3}{18.7\ mg\ rock} = 48.0\%\ CaCO_3$$

$$= 52.0\%\ SiO_2$$