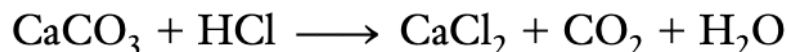# Chemical Calculations Tutorial 4

1.

Limestone, coral, and seashells are composed primarily of calcium carbonate. The test for the identification of a carbonate is to use a few drops of hydrochloric acid. The unbalanced equation is
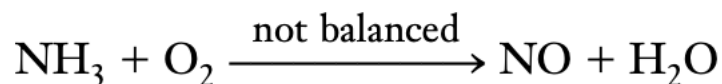
$$CaCO_3 + HCl \longrightarrow CaCl_2 + CO_2 + H_2O$$

(a) Balance the equation.
(b) How many atoms are in 0.250 moles of calcium carbonate?
(c) What number of carbon dioxide molecules is released on the reaction of 0.250 moles of calcium carbonate?

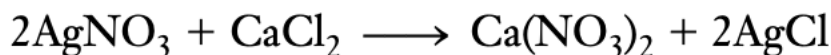$(7.52 \times 10^{21}, 2.5 \times 10^{-3})$

2.

Consider the reaction

$$NH_3 + O_2 \xrightarrow{\text{not balanced}} NO + H_2O$$

For every 25.00 mol of NH_3, (a) how many moles of O_2 are required, (b) how many moles of NO are produced, and (c) how many moles of H_2O are produced?

(31.25 mol, 25 mol, 37.5 mol)

3.

Silver nitrate solution reacts with calcium chloride solution according to the equation

$$2AgNO_3 + CaCl_2 \longrightarrow Ca(NO_3)_2 + 2AgCl$$

All of the substances involved in this reaction are soluble in water except silver chloride, AgCl, which forms a solid (precipitate) at the bottom of the flask. Suppose we mix together a solution containing 12.6 g of $AgNO_3$ and one containing 8.40 g of $CaCl_2$. What mass of AgCl is formed?

(LR AgNO₃, 10.62 g)

4.

Iron(III) oxide, Fe_2O_3, is a result of the reaction of iron with the oxygen in air.
(a) What is the balanced equation for this reaction?
(b) What number of moles of iron react with 15.25 mol of oxygen from the air?
(c) What mass of iron is required to react with 15.25 mol of oxygen?

(20.33 mol, 1138.5 g)

5.

What is the molarity of a solution of sodium hydroxide, NaOH, if 36.9 mL of this solution is required to react with 29.2 mL of 0.101 M hydrochloric acid solution according to the following reaction?

$$HCl + NaOH \longrightarrow NaCl + H_2O$$
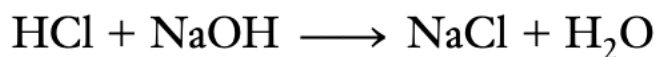
(0.08 mol dm^{-3})

6.

What is the molarity of a solution of sodium hydroxide, NaOH, if 29.8 mL of this solution is required to react with 25.0 mL of 0.0513 M nitric acid solution according to the following reaction?

$$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$$
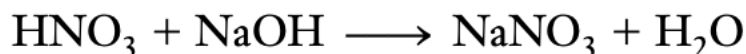
(0.043 mol dm^{-3})

7.

"Superphosphate," a water-soluble fertilizer, is sometimes marketed as "triple phosphate." It is a mixture of $Ca(H_2PO_4)_2$ and $CaSO_4$ on a 1:2 *mole* basis. It is formed by the reaction

$$Ca_3(PO_4)_2 + 2H_2SO_4 \longrightarrow Ca(H_2PO_4)_2 + 2CaSO_4$$
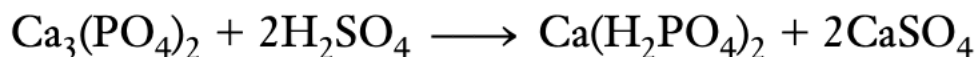
We treat 300 g of $Ca_3(PO_4)_2$ with 200 g of H_2SO_4. How many grams of superphosphate could be formed?

(226.98 g)

8.

Iron(II) chloride, $FeCl_2$, reacts with ammonia, NH_3, and water, H_2O, to produce iron(II) hydroxide, $Fe(OH)_2$, and ammonium chloride, NH_4Cl.

(a) Write the balanced equation for this reaction.

(b) We mix 78.5 g $FeCl_2$, 25.0 g NH_3, and 25.0 g H_2O, which then react as completely as possible. Which is the limiting reactant?

(c) How many grams of ammonium chloride, NH_4Cl, are formed?

(d) How many grams of each of the two leftover reactants remain at the completion of the reaction?

(LR FeCl₃, 33.06 g, 14.48 g, 2.59 g)

9.

An impure sample of solid Na_2CO_3 is allowed to react with 0.1755 M HCl.
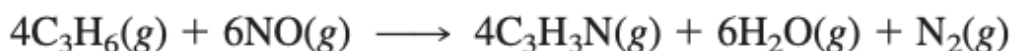
$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$
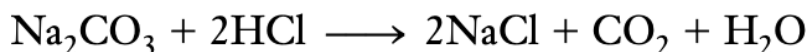
A 0.2337-g sample of sodium carbonate requires 15.55 mL of HCl solution. What is the purity of the sodium carbonate?

(61.87 %)

10.

Acrylonitrile, C_3H_3N, is the starting material for the production of a kind of synthetic fiber (acrylics). It can be made from propylene, C_3H_6, by reaction with nitric oxide, NO.
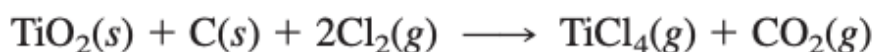
$$4C_3H_6(g) + 6NO(g) \longrightarrow 4C_3H_3N(g) + 6H_2O(g) + N_2(g)$$

How many grams of acrylonitrile are obtained from 452 kg of propylene and excess NO?

(53 ×10⁴ g)

11.

A titanium ore contains rutile (TiO_2) plus some iron oxide and silica. When it is heated with carbon in the presence of chlorine, titanium tetrachloride, $TiCl_4$, is formed.

$$TiO_2(s) + C(s) + 2Cl_2(g) \longrightarrow TiCl_4(g) + CO_2(g)$$

Titanium tetrachloride, a liquid, can be distilled from the mixture. If 35.4 g of titanium tetrachloride is recovered from 17.4 g of crude ore, what is the mass percentage of TiO_2 in the ore (assuming all TiO_2 reacts)?

84.48 %

12.

A sample of limestone (containing calcium carbonate, $CaCO_3$) weighing 438 mg is treated with oxalic acid, $H_2C_2O_4$, to give calcium oxalate, CaC_2O_4.

$$CaCO_3(s) + H_2C_2O_4(aq) \longrightarrow$$
$$CaC_2O_4(s) + H_2O(l) + CO_2(g)$$
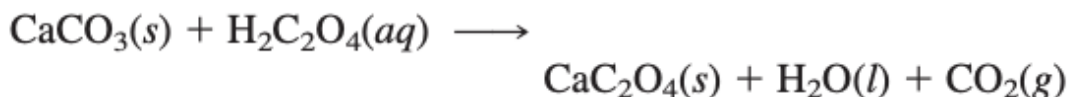
The mass of the calcium oxalate produced is 472 mg. What is the mass percentage of calcium carbonate in this limestone?

(84.18 %)

13.

a. Calculate the volume of a 0.225 M solution of potassium hydroxide, KOH, required to react with 0.215 g of acetic acid, CH_3COOH, according to the following reaction.

$$KOH + CH_3COOH \longrightarrow KCH_3COO + H_2O$$

b. Calculate the number of grams of carbon dioxide, CO_2, that can react with 135 mL of a 0.357 M solution of potassium hydroxide, KOH, according to the following reaction.

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$
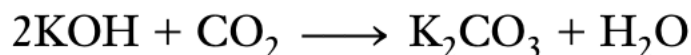
c. What volume of 0.246 M HNO_3 solution is required to react completely with 38.6 mL of 0.0515 M $Ba(OH)_2$?

$$Ba(OH)_2 + 2HNO_3 \longrightarrow Ba(NO_3)_2 + 2H_2O$$
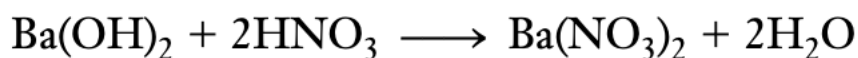
d. What volume of 0.55 M HBr is required to react completely with 0.80 mol of $Ca(OH)_2$?

$$2HBr + Ca(OH)_2 \longrightarrow CaBr_2 + 2H_2O$$
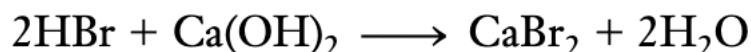
e. An excess of $AgNO_3$ reacts with 185.5 mL of an $AlCl_3$ solution to give 0.325 g of AgCl. What is the concentration, in moles per liter, of the $AlCl_3$ solution?

$$AlCl_3 + 3AgNO_3 \longrightarrow 3AgCl + Al(NO_3)_3$$
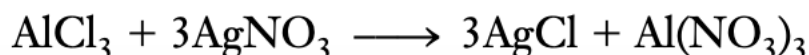
a. 15.91 mL b. 1.056 g c. 161.6 mL d. 2.9 mL. e. 4.05×10^{-3} mol dm^{-3}

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