**Stoichiometry in the Real World**

- **Air Bag Design**
  - Exact quantity of nitrogen gas must be produced in an instant.
  - Use a **catalyst** to speed up the reaction

\[
2 \text{NaN}_3(s) \rightarrow 2 \text{Na}(s) + 3 \text{N}_2(g)
\]

\[
6 \text{Na}(s) + \text{Fe}_2\text{O}_3(s) \rightarrow 3 \text{Na}_2\text{O}(s) + 2 \text{Fe}(s)
\]

- Water from a Camel
  - Camels store the fat tristearin (C_{38}H_{70}O_6) in the hump. As well as being a source of energy, the fat is a source of water, because when it is used the reaction

\[
2 \text{C}_{38}\text{H}_{70}\text{O}_6(s) + 163 \text{O}_2(g) \rightarrow 114 \text{CO}_2(g) + 110 \text{H}_2\text{O}(l)
\]

\[
x \text{g H}_2\text{O} = \frac{1 \text{ kg fat}}{1 \text{ kg fat}} \times \frac{1000 \text{ g fat}}{1000 \text{ g fat}} \times \frac{1 \text{ mol Na}}{1 \text{ mol Na}} \times \frac{1 \text{ mol Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{59.6 \text{ g Fe}_2\text{O}_3}{59.6 \text{ g Fe}_2\text{O}_3}
\]

\[
X = 37.7 \text{ g Fe}_2\text{O}_3
\]

- Rocket Fuel
  - The compound diborane (B_2H_6) was at one time considered for use as a rocket fuel. How many grams of liquid oxygen would a rocket have to carry to burn 10 kg of diborane completely? (The products are B_2O_3 and H_2O).

Chemical equation

\[
\text{B}_2\text{H}_6 + \text{O}_2 \rightarrow \text{B}_2\text{O}_3 + \text{H}_2\text{O}
\]

Balanced chemical equation

\[
\text{B}_2\text{H}_6 + 3 \text{O}_2 \rightarrow 2 \text{B}_2\text{O}_3 + 3 \text{H}_2\text{O}
\]

\[
x \text{g O}_2 = \frac{10 \text{ kg B}_2\text{H}_6}{10 \text{ kg B}_2\text{H}_6} \times \frac{1 \text{ mol B}_2\text{H}_6}{1 \text{ mol B}_2\text{H}_6} \times \frac{1 \text{ mol O}_2}{1 \text{ mol B}_2\text{H}_6} \times \frac{32 \text{ g O}_2}{1 \text{ mol O}_2}
\]

\[
X = 34,286 \text{ g O}_2
\]

- Water in Space
  - In the space shuttle, the CO_2 that the crew exhales is removed from the air by a reaction within canisters of lithium hydroxide. On average, each astronaut exhales about 20.0 mol of CO_2 daily. What volume of water will be produced when this amount of CO_2 reacts with an excess of LiOH? (Hint: The density of water is about 1.00 g/mL.)

\[
\text{CO}_2(g) + 2 \text{LiOH}(s) \rightarrow \text{Li}_2\text{CO}_3(aq) + \text{H}_2\text{O}(l)
\]

\[
x \text{ mol H}_2\text{O} = \frac{20.0 \text{ mol CO}_2}{2 \text{ mol CO}_2} \times \frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol CO}_2} \times \frac{1 \text{ mL H}_2\text{O}}{1 \text{ g H}_2\text{O}}
\]

\[
X = 360 \text{ mL H}_2\text{O}
\]
Lithium Hydroxide Scrubber

Modified by Apollo 13 Mission

Astronaut John L. Swigert holds the jury-rigged lithium hydroxide scrubber used to remove excess carbon dioxide from the damaged Apollo 13 spacecraft.

Real Life Problem Solving

Determine the amount of LiOH required for a seven-day mission in space for three astronauts and one ‘happy’ chimpanzee. Assume each passenger expels 20 mol of CO₂ per day.

Note: The lithium hydroxide scrubbers are only 85% efficient.

(4 passengers) x (10 days) x (20 mol/day) = 800 mol CO₂

Plan for a delay

CO₂(g) + 2 LiOH(s) → Li₂CO₃(aq) + H₂O(l)

800 mol x g

Careers in Chemistry: Farming

Farming is a big business in the United States with profits for the lucky and possible bankruptcy for the less fortunate. Farmers should not be ignorant of chemistry. For instance, to be profitable, a farmer must know when to plant, harvest, and sell his/her crops to maximize profit. In order to get the greatest yield, farmers often add fertilizers to the soil to replenish vital nutrients removed by the previous season’s crops.

Corn is one product that removes a tremendous amount of phosphorus from the soil. For this reason, farmers will rotate crops and/or add fertilizer to the ground before planting crops for the following year. On average, an acre of corn will remove 6 kilograms of phosphorus from the ground.

Assume you inherit a farm and must now have to purchase fertilizer for the farm. The farm is 340 acres and had corn planted the previous year. You must add fertilizer to the soil before you plant this year’s crop. You plan to go to the local fertilizer store and find SuperPhosphate® brand fertilizer. You read the fertilizer bag and can recognize from your high school chemistry class a molecular formula Ca₃(PO₄)₂(SO₄)₂ (you don’t understand anything else written on the bag because it is imported fertilizer from Japan). You must decide how much fertilizer to buy for 340 acres and what fertilizer must you purchase and how much will it cost you to add the necessary fertilizer to your field?

Given: 1 bag of fertilizer weighs 10,000 g (454 g = 1 pound)

Water in Space

In the space shuttle, the CO₂ that the crew exhales is removed from the air by a reaction within canisters of lithium hydroxide. On average, each astronaut exhales about 20.0 mol of CO₂ daily. What volume of water will be produced when this amount of CO₂ reacts with an excess of LiOH?

(Hint: The density of water is about 1.00 g/mL.)

CO₂(g) + 2 LiOH(s) → Li₂CO₃(aq) + H₂O(l)

20.0 mol excess

x mL H₂O = 20.0 mol CO₂

800 mol            x g

1 mol H₂O  1 mol LiOH  1 mL H₂O

1 mol CO₂  1 mol LiOH  1 g H₂O

X = 360 mL H₂O

Careers in Chemistry: Farming

How much fertilizer will you need?

Conversion Factor: 1 acre corn = 6 kg phosphorous

x g P = 340 acres × 6 kg phosphorous / 1 acre corn = 204 × 10⁴ g P

If a bag of fertilizer has the formula Ca₃(PO₄)₂(SO₄)₂,

The molar mass of it is 596 g/mol.

In a bag of fertilizer you have 10.4% by mass phosphorus.

A bag of fertilizer weight 10,000 g (about 22 pounds)

10.4% of 10,000 g = 1,040 g phosphorous / bag of fertilizer

2,080 x 10⁴ g P × 1842 bags of fertilizer

Total Cost: 1842 bags of fertilizer ($54.73 / bag) = $107,380
Careers in Chemistry: Dentistry

We learned that fluoride is an essential element to be taken to reduce teeth cavities. Too much fluoride can produce yellow spots on the teeth and too little will have no effect. After years of study it was determined that a quantity of 1 part per million (ppm) fluoride in the water supply is enough to significantly reduce cavities and not stain teeth yellow.

Measure the mass of the mineral fluorite (chemically, CaF$_2$). Use this sample to determine how much water must be added to yield a 1 ppm fluoride solution. Sounds difficult? Let's apply what we've learned this unit to solve this problem.

1 part per million = 1 atom of fluorine per 999,999 water molecules

What information do we know:
- 1 mol CaF$_2$ = 78.08 g CaF$_2$ = 6.02 x 10$^{23}$ molecules of CaF$_2$
- 1 molecules of CaF$_2$ = 2 atoms of F
- 1 mol H$_2$O = 18 g H$_2$O Density of water is 1 g/mL
- 1000 mL = 1 L and 3.78 L = 1 gallon
- mass of sample of CaF$_2$ = 92.135 g

Energy with Stoichiometry

Given: 1 mol O$_2$ yields 350 kJ

methane + oxygen $\rightarrow$ carbon dioxide + water + energy

Excess Limiting

CH$_4$ + 2O$_2$ $\rightarrow$ CO$_2$ + 2H$_2$O + 700 kJ

100 g 100 g

/16 g/mol /32 g/mol

6.25 x molO$_2$ 3.125 x molO$_2$

1 2

6.25 1.56

smaller number is limiting reactant

\[ x \text{ kJ} = 3.125 \text{ mol} \text{O}_2 \times \frac{700 \text{ kJ}}{x \text{ mol} \text{O}_2} = 1094 \text{ kJ} \]