Chemistry Boot Camp
Summer 2013
Vanden Bout/LaBrake
Active Learning Session 2 – Gas Stoichiometry

Name: KEY

Below is an unbalanced chemical equation for the combustion of propane gas.

$$C_3H_8\,(g) + 5O_2\,(g) \rightarrow 3CO_2\,(g) + 4H_2O\,(g)$$

1. Balance the equation.

2. If you have 10L of C_3H_8 gas in a container at 298K and a pressure of 1 atm, how many liters of O_2 gas do you need to **completely** combust the propane? $V \propto n$

Given: 10 L C_3H_8
Wanted: ? L O_2
Conversion: 1 L C_3H_8 : 5 L O_2

$$\frac{10\,L\,C_3H_8 \mid 5\,L\,O_2}{\mid 1\,L\,C_3H_8} = \boxed{50\,L\,O_2}$$

3. If you have a 20 L mixture of propane and oxygen gas with a mole fraction of propane, $X_{C_3H_8} = 0.2$, is there sufficient oxygen for complete combustion? Explain. $\boxed{NO}$

If $X_{C_3H_8} = .2$, then $X_{O_2} = .8$ this is a 1:4 ratio
However from the balanced equation the ratio is 1:5.

*In general to avoid any side reaction you need an **excess of oxygen** for complete combustion. This is a very important fact, as people who combust fuels in a reduced oxygen environment can accidentally cause asphyxiation by the production of CO.*

4. Assume you start with 4L of propane and 26 L of oxygen gas, both held a constant temperature and pressure. Assume that under these conditions, the reaction will be complete combustion (forming CO_2 and H_2O as products). After the reaction will the volume of the container be the larger, smaller, or the same? What will the volume of the container be (or do you need more information for a quantitative answer)?

C_3H_8 is limiting reagent

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

$$\frac{4\,L\,C_3H_8 \mid 5\,L\,O_2}{\mid 1\,L\,C_3H_8} = 20\,L\,O_2 \text{ used} \qquad \frac{4\,L\,C_3H_8 \mid 3\,L\,CO_2}{\mid 1\,L\,C_3H_8} = 12\,L\,CO_2 \text{ produced}$$

*Now, assume that your combustion is **not complete** as the reaction will produce some carbon monoxide, CO, in addition to the CO_2. Writing and balancing an incomplete combustion is not trivial.*

$$\frac{4\,L\,C_3H_8 \mid 4\,L\,H_2O}{\mid 1\,L\,C_3H_8} = 16\,L\,H_2O \text{ produced}$$

6 L O_2 leftover
12 L CO_2 produced
16 L H_2O produced

Initial Volume 4L + 26L = 30L

LARGER →

34 L Final Volume

5. Taking as the starting conditions 1 mole of propane and 5 moles of oxygen now held at constant volume of 20L and constant temperature of 300K. If the 1% of the total carbon forms CO, what is the partial pressure of CO after the reaction?

a) How much total C in rxn mixture?

$1 \text{ mol } C_3H_8 = \boxed{3 \text{ mol C}}$

b) How many moles CO formed?

$3 \text{ mol C} \times .01 = \boxed{.03 \text{ mol CO}}$

c) What is the partial pressure of CO in final mixture?

$P_{CO}V_{CO} = n_{CO}RT_{CO}$

$V = 20\text{ L}$

$n = .03 \text{ mol}$

$R = .08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$

$T = 300\text{K}$

$P_{CO} = \frac{nRT}{V} = \frac{.03 \cdot .08206 \cdot 300}{20}$

$\boxed{P_{CO} = .037 \text{ atm}}$