CHEM110 – Chapter 3 Chemical Reactions and Stoichiometry

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3.5 Stoichiometry

- **Stoichiometry → the mole-to-mole ratio linking substances involved in a chemical equation**

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

  - **Interpret in terms of molecules or on a molar scale**
  - **Mole-to-mole relationships can be used to solve stoichiometry problems**
  - **Equations must be balanced**

Worked Example 3.8 – page 83

What amount of sodium phosphate, Na_3PO_4, can be made from 0.240 mol of NaOH by the following reaction?

$$2NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

Worked Example 3.9 – page 85

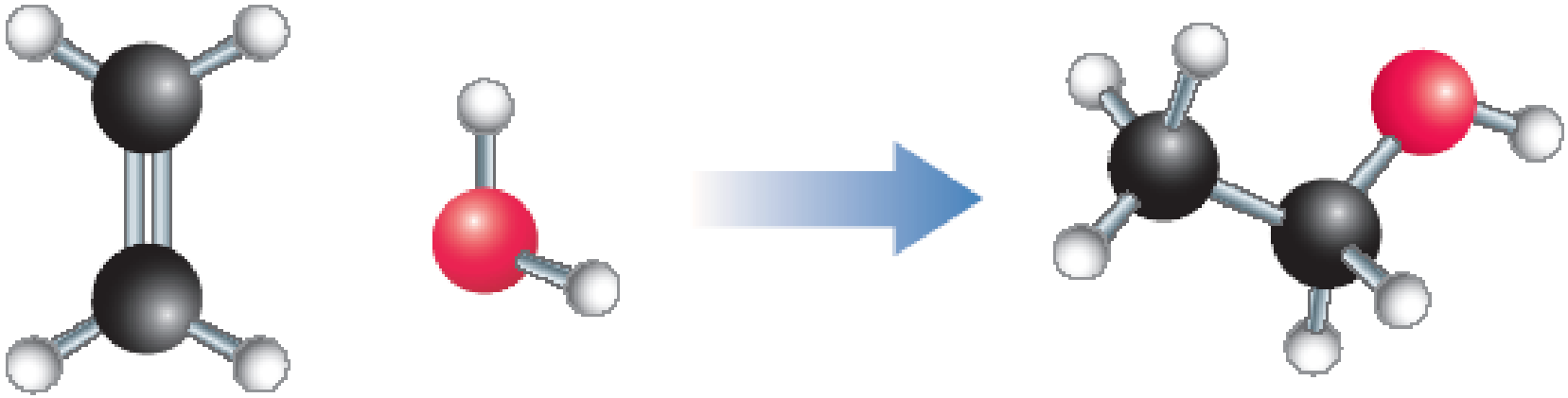
Metallic iron can be made by the thermite reaction of aluminium with iron oxide, Fe_2O_3. So much heat is generated that the iron forms in the liquid state. The equation is:

$$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(l)$$

Assume that you need to product 86.0 g of Fe in a welding operation. What mass of both Fe_2O_3 and Al must be used for this operation, assuming all the Fe_2O_3 is converted to Fe.

3.5 Limiting Reactants

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

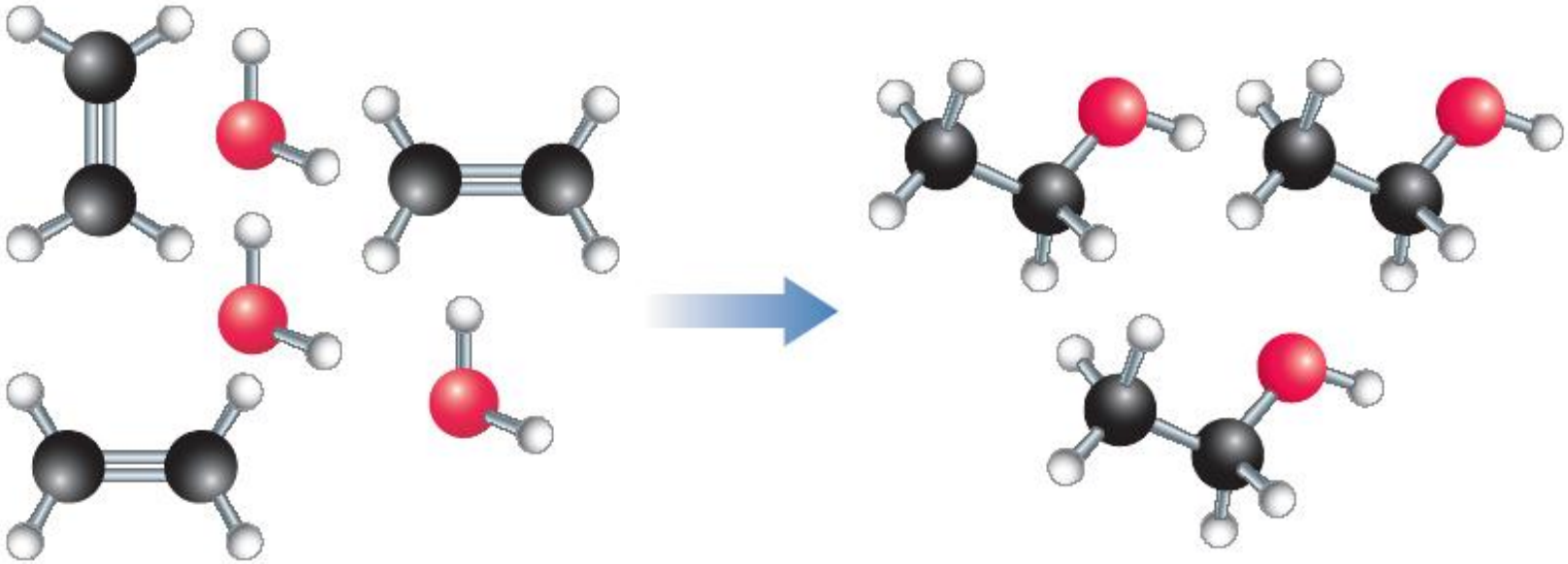


ethene water ethanol

before reaction after reaction

3.5 Limiting Reactants

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

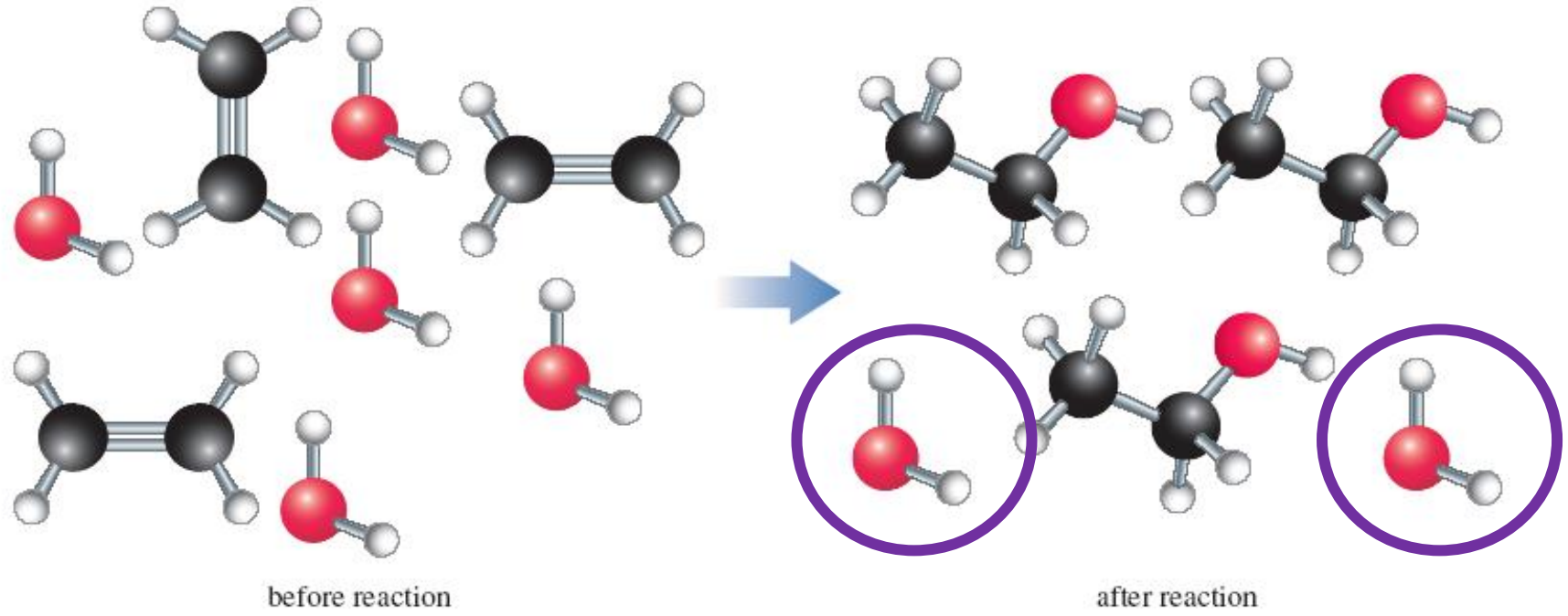


before reaction

after reaction

3.5 Limiting Reactants

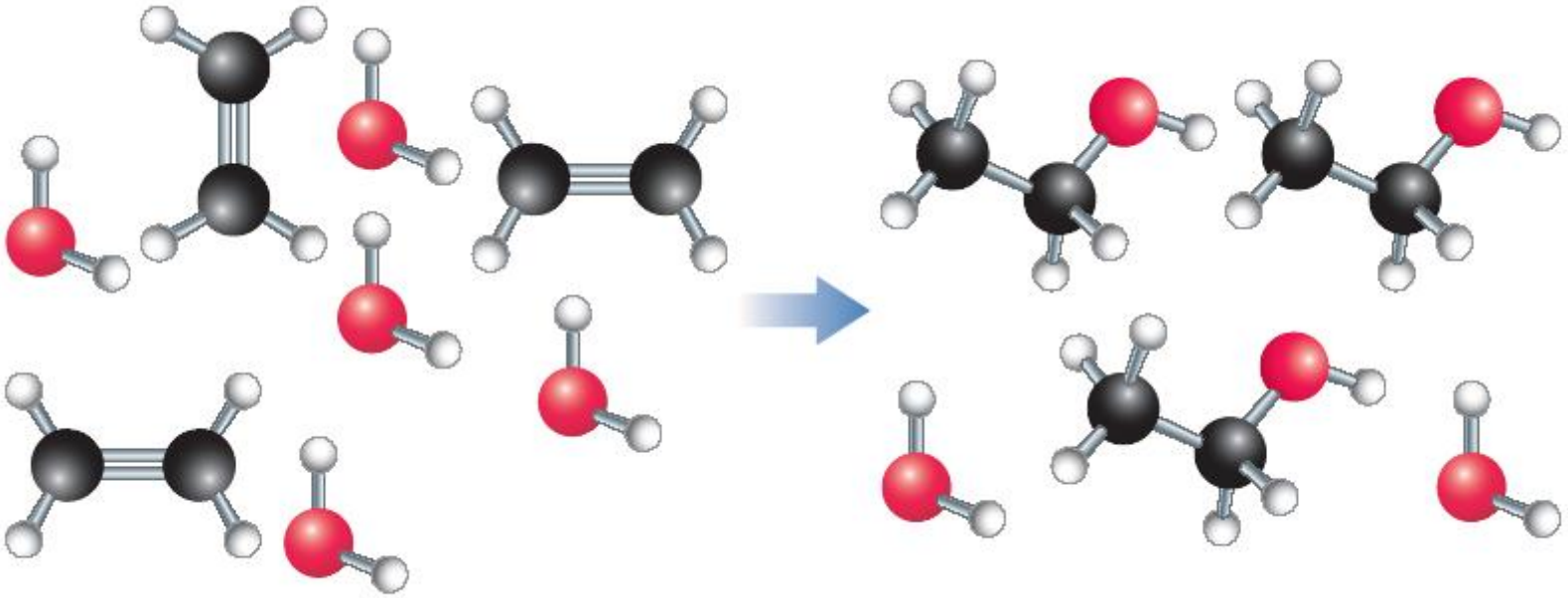
$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$



before reaction

after reaction

3.5 Limiting Reactants



In THIS case →

- **C_2H_4 is the LIMITING REACTANT**
- **H_2O is the EXCESS REACTANT**

3.5 Limiting Reactants

The calculated amount of product is always based on the limiting reactant

Worked Example 3.10 – page 87

Gold (II) hydroxide, $Au(OH)_3$, is used for electroplating gold onto other metals. It can be made by the following reaction:

$2KAuCl_4(aq) + 3Na_2CO_3(aq) + 3H_2O(l) \rightarrow 2Au(OH)_3(s) + 6NaCl(aq) + 2KCl(aq) + 3CO_2(g)$

To prepare a fresh supply of $Au(OH)_3$, a chemist at an electroplating plant mixed 20.00 g of $KAuCl_4$ with 25.00 g of Na_2CO_3 (both dissolved in a large excess of water). What is the maximum mass of $Au(OH)_3$ that can form?

Which of these “reactions” has a limiting and excess reactant?

A. 4 table tops and 16 table legs
B. 1 table top and 4 table legs
C. 10 table tops and 40 table legs
D. 5 table tops 15 table legs

3.5 Percentage Yield

- **Experimentally the amount of a product isolated falls short of the maximum amount**

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

- **The calculation may be done in either grams or moles BUT units must be the same for both yields**
- **The actual yield can never be more than the theoretical yield**

Worked Example 3.11 – page 88

A chemist sets up a synthesis of phosphorous trichloride, PCl_3, by mixing 12.0 g of P with 35.0 g of Cl_2 and obtained 42.4 g of PCl_3. The equation for the reaction is: $2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(l)$

Calculate the percentage yield of this compound.