Chemistry Lecture #60: Limiting Reactants (Mass-to-Mass)

Suppose we have a chemical equation for making a pie.

2 eggs + 4 apples → 1 pie

How many pies can be made with 6 eggs and 8 apples?

$$\frac{6 \text{ eggs}}{1} \times \frac{1 \text{ pie}}{2 \text{ eggs}} = 3 \text{ pies}$$

$$\frac{8 \text{ apples}}{1} \times \frac{1 \text{ pie}}{4 \text{ apples}} = 2 \text{ pies}$$ smaller number of pies

With 6 eggs we can make 3 pies, but with 8 apples we can only make 2 pies. The number of apples limits the amount of pie we can make. The apples are the limiting reactant. We can't make 3 pies, but we do have enough material to make 2.

To solve limiting reactant problems, convert *both* knowns to unknowns, then pick the smallest value.

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

How many grams of ZnO can be made from 418 g of ZnS and 264 g of O_2?

Notice that there are two knowns: ZnS and O_2. We solve the amount of ZnO we can get from 418 g of ZnS. Then we solve the amount of ZnO we can get from 264 g of O_2.

418 g known 264 g known ? g unknown

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

ZnS = 97.5 g/mole ZnO = 81.4 g/mole

O_2 = 32.0 g/mole

$$\frac{418 \text{ g ZnS}}{1} \times \frac{\text{mole ZnS}}{97.5 \text{ g Zns}} \times \frac{2 \text{ moles ZnO}}{2 \text{ moles ZnS}} \times \frac{81.4 \text{ g ZnO}}{\text{mole ZnO}}$$

$$= 349 \text{ g ZnO}$$

$$\frac{264 \text{ g } O_2}{1} \times \frac{\text{mole } O_2}{32.0 \text{ g } O_2} \times \frac{2 \text{ moles ZnO}}{3 \text{ moles } O_2} \times \frac{81.4 \text{ g ZnO}}{\text{moles ZnO}}$$

$$= 448 \text{ g ZnO}$$

Since 349 is less than 448, the actual amount of ZnO we'll get is 349 g. ZnS is the limiting reactant.

You can also use the formula introduced in lecture #59 if you have difficulty using the factor-label method.

418 g known 264 g known ? g unknown

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

ZnS = 97.5 g/mole ZnO = 81.4 g/mole

O_2 = 32.0 g/mole

With ZnS as the known,

U_g = ? K_g = 418 g C_u = 2

M_u = 81.4 g/mole M_k = 97.5 g/mole C_k = 2

$$U_g = \frac{K_g C_u M_u}{M_k C_k} = \frac{(418)(2)81.4)}{(97.5)(2)} = 349 \text{ g ZnO}$$

With ZnO as the known,

U_g = ? K_g = 264 g C_u = 2

M_u = 81.4 g/mole M_k = 32.0 g/mole C_k = 3

$$U_g = \frac{K_g C_u M_u}{M_k C_k} = \frac{(264)(2)81.4)}{(32.0)(3)} = 448 \text{ g ZnO}$$

Since 349 is less than 448, the actual amount of ZnO we'll get is 349 g. ZnS is the limiting reactant.