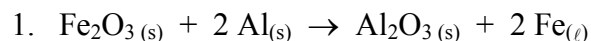


## Stoichiometry Workshop - Solutions



$$150 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \frac{2 \text{ mol Fe}}{2 \text{ mol Al}} \times \frac{55.85 \text{ g Fe}}{1 \text{ mol Fe}} = 311 \text{ g Fe}$$

$$250 \text{ g Fe}_2\text{O}_3 \times \frac{1 \text{ mol Fe}_2\text{O}_3}{159.70 \text{ g Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{55.85 \text{ g Fe}}{1 \text{ mol Fe}} = 175 \text{ g Fe}$$

$\text{Fe}_2\text{O}_3$  is the limiting reagent, and 175 g Fe is produced from this reaction.

2. Consider 100.0 g of vitamin A:

$$100.00 \text{ g vitamin A} \times \frac{1 \text{ mol vitamin A}}{286.4 \text{ g vitamin A}} = 0.3492 \text{ mol vitamin A}$$

$$83.86 \text{ g C} \times \frac{1 \text{ mol C}}{12.011 \text{ g C}} = 6.982 \text{ mol C}$$

$$\frac{6.982 \text{ mol C}}{0.3492 \text{ mol vitamin A}} = \frac{19.99 \text{ mol C}}{1 \text{ mol vitamin A}} \approx \frac{20 \text{ mol C}}{1 \text{ mol vitamin A}}$$

$$10.56 \text{ g H} \times \frac{1 \text{ mol H}}{1.0079 \text{ g H}} = 10.48 \text{ mol H}$$

$$\frac{10.48 \text{ mol H}}{0.3492 \text{ mol vitamin A}} = \frac{30.01 \text{ mol H}}{1 \text{ mol vitamin A}} \approx \frac{30 \text{ mol H}}{1 \text{ mol vitamin A}}$$

$$\frac{(100 - 83.86 - 10.56) \text{ g E}}{0.3492 \text{ mol vitamin A}} = \frac{15.98 \text{ g E}}{1 \text{ mol vitamin A}} \times \frac{1 \text{ mol vitamin A}}{1 \text{ mol E}} = \frac{15.98 \text{ g E}}{1 \text{ mol E}}$$

The molecular weight of E is 15.98 g/mol, which suggests that E is oxygen (O) and the molecular formula of vitamin A is  $\text{C}_{20}\text{H}_{30}\text{O}$ .

3. a. By conservation of mass:

$$(24.96 \text{ g CO}_2 + 12.27 \text{ g H}_2\text{O}) - (10.00 \text{ g C}_5\text{H}_{12}\text{O}) = 27.23 \text{ g O}_2$$

$$b. 24.96 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} = 0.5671 \text{ mol C} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 6.811 \text{ g C}$$

$$12.27 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} = 1.362 \text{ mol H} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} = 1.373 \text{ g H}$$

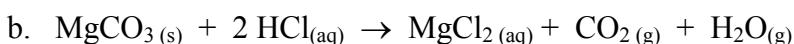
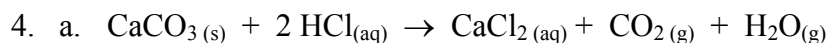
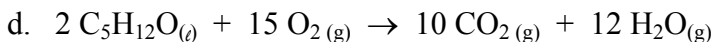
$$\text{mass of O} = (10.00 \text{ g MTBE}) - (6.811 \text{ g C}) - (1.373 \text{ g H}) = 1.82 \text{ g O}$$

$$1.82 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 0.1135 \text{ mol O}$$

Dividing each mole value by 0.1135 yields a mole ratio of 5 C : 12 H : 1 O.

The empirical formula is thus  $(C_5H_{12}O)_n$ , which has a formula weight of 88.15 amu.

- c. The MTBE vapor has a mass about twice the mass of an equal volume of carbon dioxide gas at the same temperature and pressure. This implies that the molecular mass of MTBE is 2 times the molecular mass of carbon dioxide gas, which is 44.01 amu. Thus, the molecular mass of the sample must be  $\approx 88$  amu. The mass of the empirical formula unit  $C_5H_{12}O$  is 88.15 amu. Thus,  $n = 1$ , and the molecular formula of MTBE must be  $C_5H_{12}O$ .



- c. 1.000 g of lime contains 0.800 g  $CaCO_3$  and 0.200 g  $MgCO_3$ .

$$0.800 \text{ g } CaCO_3 \times \frac{1 \text{ mol } CaCO_3}{100.05 \text{ g } CaCO_3} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } CaCO_3} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 0.352 \text{ g } CO_2$$

$$0.200 \text{ g } MgCO_3 \times \frac{1 \text{ mol } MgCO_3}{84.32 \text{ g } MgCO_3} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } MgCO_3} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 0.104 \text{ g } CO_2$$

$$\text{total } CO_2 = (0.352 \text{ g}) + (0.104 \text{ g}) = 0.456 \text{ g } CO_2$$

- d. 1.000 g of lime contains 0.800 g  $CaCO_3$  and 0.200 g  $MgCO_3$ .

$$0.800 \text{ g } CaCO_3 \times \frac{1 \text{ mol } CaCO_3}{100.05 \text{ g } CaCO_3} \times \frac{2 \text{ mol } HCl}{1 \text{ mol } CaCO_3} \times \frac{36.46 \text{ g } HCl}{1 \text{ mol } HCl} = 0.583 \text{ g } HCl$$

$$0.200 \text{ g } MgCO_3 \times \frac{1 \text{ mol } MgCO_3}{84.32 \text{ g } MgCO_3} \times \frac{2 \text{ mol } HCl}{1 \text{ mol } CaCO_3} \times \frac{36.46 \text{ g } HCl}{1 \text{ mol } HCl} = 0.173 \text{ g } HCl$$

$$\text{total } HCl = (0.583 \text{ g}) + (0.173 \text{ g}) = 0.756 \text{ g } HCl$$

- e. 1.000 g mixture = (x g  $CaCO_3$ ) + (y g  $MgCO_3$ )

$$x \text{ g } CaCO_3 \times \frac{1 \text{ mol } CaCO_3}{100.05 \text{ g } CaCO_3} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } CaCO_3} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 0.440x \text{ g } CO_2 \text{ from } CaCO_3$$

$$y \text{ g } MgCO_3 \times \frac{1 \text{ mol } MgCO_3}{84.32 \text{ g } MgCO_3} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } MgCO_3} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 0.522y \text{ g } CO_2 \text{ from } MgCO_3$$

$$0.500 \text{ g } CO_2 = (0.440x \text{ g } CO_2 \text{ from } CaCO_3) + (0.522y \text{ g } CO_2 \text{ from } MgCO_3)$$

$$0.500 \text{ g } CO_2 = (0.440x \text{ g } CO_2) + (0.522 \times (1.000 - x) \text{ g } CO_2)$$

$$0.500 \text{ g } CO_2 = 0.522 \text{ g } CO_2 - 0.082x \text{ g } CO_2$$

$$x = \frac{(0.522 - 0.500) \text{ g } CO_2}{0.082 \text{ g } CO_2} = 0.268$$

The mixture contains 0.268 g  $CaCO_3$  and 0.732 g  $MgCO_3$ .