

CHEM 103

R&R 6

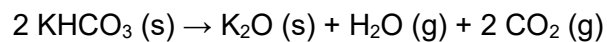
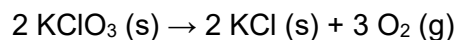
6 June 2024

Adapted from a 10 June 2020 document

1. Vanillin, the dominant flavoring in vanilla, contains C, H, and O. When 1.05 g of this substance is completely combusted, 2.43 g  $\text{CO}_2$  and 0.50 g  $\text{H}_2\text{O}$  are produced. What is the empirical formula of vanillin?

2. A mixture of  $\text{N}_2$  (g) and  $\text{H}_2$  (g) reacts in a closed container to form ammonia,  $\text{NH}_3$  (g). The reaction ceases before either reactant has been totally consumed. At this stage, 3.0 mol  $\text{N}_2$ , 3.0 mol  $\text{H}_2$ , and 3.0 mol  $\text{NH}_3$  are present. How many moles of  $\text{N}_2$  and  $\text{H}_2$  were present originally?

3. A mixture containing  $\text{KClO}_3$ ,  $\text{KHCO}_3$ ,  $\text{K}_2\text{CO}_3$ , and  $\text{KCl}$  was heated, producing  $\text{CO}_2$ ,  $\text{O}_2$ , and  $\text{H}_2\text{O}$  gases according to the following equations:



The  $\text{KCl}$  and  $\text{K}_2\text{O}$  do not react under the conditions of the reaction. If 100.0 g of the mixture produces 1.80 g  $\text{H}_2\text{O}$ , 13.20 g  $\text{CO}_2$ , and 4.00 g  $\text{O}_2$ , what was the composition of the original mixture? (Assume complete decomposition of the mixture.)

4. Your friend has heard that she can make ethanol by reacting  $\text{C}_2\text{H}_4$  with  $\text{H}_2\text{O}$  under acidic conditions, but she's not sure how much of each starting material she needs. She randomly mixes 101.7 g  $\text{C}_2\text{H}_4$  with 55.19 g  $\text{H}_2\text{O}$ .



a. What is the theoretical yield of ethanol in mL? (ethanol density =  $0.789 \text{ g mL}^{-1}$ )

b. Which reactant is in excess? How much of it remains, by mass?

5. Complete and balance the following molecular equations, and then write the net ionic equation for each. (Note: in past answer keys, we have written  $\text{H}^+$  in net ionic equations, but it is more correct to write  $\text{H}_3\text{O}^+$  instead.  $\text{H}^+$  doesn't actually exist by itself in solution.)

a.  $\text{HBr (aq)} + \text{NH}_3 \text{ (aq)} \rightarrow$

b. Aqueous hydrochloric acid and sodium acetate

c. Aqueous perchloric acid and aqueous strontium hydroxide

6. Give the oxidation number of each element in the following compounds:

- a.  $\text{BrO}_3^-$   
b.  $\text{H}_2\text{SO}_4$   
c.  $\text{CrO}_4^{2-}$   
d.  $\text{HCO}_3^-$   
e.  $\text{LiAlH}_4$

7. Starting with solid sucrose,  $C_{12}H_{22}O_{11}$ , describe how you would:

- a. Prepare 250 mL of a 0.250 M sucrose solution

- b. Prepare 350.0 mL of 0.100 M  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  starting with 3.00 L of 1.50 M  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

- c. (Optional) if you have some beverage that contains sucrose—lemonade, soft drink, etc.—calculate the molarity of sucrose for that drink.

8. A 0.180 g sample of caffeine is combusted to yield 0.326 g CO<sub>2</sub>, 0.0835 g H<sub>2</sub>O, and 0.171 g NO<sub>2</sub>. The molar mass of caffeine is 194.20 g mol<sup>-1</sup>.

a. Provide the empirical and molecular formulae for caffeine.

b. According to a cursory Google search, 237 mL of coffee contains 95 mg of caffeine. What is the concentration of caffeine in coffee?