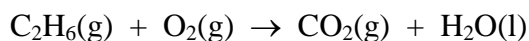# 4 • Chemical Equations and Stoichiometry

STUDY QUESTIONS AND PROBLEMS
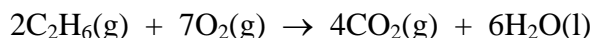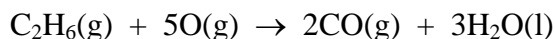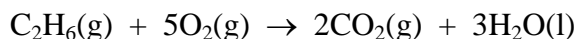
1. Balance the following equations:

   a. $\_\_C_4H_6(g) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(l)$

   b. $\_\_NH_3(g) + \_\_O_2(g) \rightarrow \_\_NO_2(g) + \_\_H_2O(l)$

   c. $\_\_PCl_3(l) + \_\_H_2O(l) \rightarrow \_\_H_3PO_3(aq) + \_\_HCl(aq)$

   d. $\_\_Ca_3P_2(s) + \_\_H_2O(l) \rightarrow \_\_Ca(OH)_2(aq) + \_\_PH_3(g)$

   e. $\_\_C_4H_8(OH)_2(l) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(l)$

   f. $\_\_NH_3(g) + \_\_NO(g) \rightarrow \_\_N_2(g) + \_\_H_2O(l)$

   g. $\_\_KClO_3(s) \rightarrow \_\_KCl(s) + \_\_O_2(g)$

   h. $\_\_Ca(OH)_2(s) + \_\_H_3PO_4(aq) \rightarrow \_\_Ca_3(PO_4)_2(s) + \_\_H_2O(l)$

   i. $\_\_C_3H_8(g) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(l)$

   j. $\_\_N_2O(g) + \_\_O_2(g) \rightarrow \_\_NO_2(g)$

   k. $\_\_Al_4C_3(s) + \_H_2O(l) \rightarrow \_\_Al(OH)_3(aq) + \_\_CH_4(g)$

   l. $\_\_CS_2(l) + \_\_Cl_2(g) \rightarrow \_\_CCl_4(l) + \_\_S_2Cl_2(l)$

   m. $\_\_C_2H_5OH(l) + \_\_PCl_3(l) \rightarrow \_\_C_2H_5Cl(l) + \_\_H_3PO_3(l)$

   n. $\_\_ZnS(s) + \_\_O_2(g) \rightarrow \_\_ZnO(s) + \_\_SO_2(g)$

   o. $\_\_Ag(s) + \_\_H_2S(g) + \_\_O_2(g) \rightarrow \_\_Ag_2S(s) + \_\_H_2O(l)$

3. When asked to balance the equation:

   $$C_2H_6(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

   the following suggestions were made:

   $$C_2H_6(g) + 5O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

   $$C_2H_6(g) + 5O(g) \rightarrow 2CO(g) + 3H_2O(l)$$

   $$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

   Which answer is correct and what is wrong with the others?

4. Write balanced chemical equations for the following reactions:

   a. the decomposition of ammonium nitrate to nitrogen gas, oxygen gas, and water vapor.
   b. the reaction of sodium bicarbonate with sulfuric acid to produce sodium sulfate, water, and carbon dioxide.
   c. the treatment of phosphorus pentachloride with water to produce phosphoric acid and hydrogen chloride.

5. If the maximum amount of product possible is formed in the following reactions, what mass of the specified product would you obtain?

    a.   10 grams of sodium chloride is treated with excess silver nitrate:

          $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

          How much silver chloride is precipitated?

    b.   12 grams copper metal is treated with excess dilute nitric acid:

          $3Cu(s) + 8HNO_3(aq) \rightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$

          How much nitric oxide gas (NO) is produced?

    c.   60 grams propane gas is burned in excess oxygen:

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

          How much water is produced?

6. A furniture dealer put together a special deal for the annual sale—an entire dining room set comprising a table, six dining chairs, two bookshelves, a china cabinet, and a sideboard for $999. The dealer had in stock 280 tables, 1750 chairs, 550 bookshelves, 300 china cabinets, and 325 sideboards. He asked his assistant to figure out how many dining room sets they could sell, how much money they would make if they sold all the sets possible, and what they would have left that could not be sold as part of the deal.

7. Hydrazine reacts with dinitrogen tetroxide according to the equation:

    $2N_2H_4(g) + N_2O_4(g) \rightarrow 3N_2(g) + 4H_2O(g)$

    50.0 grams of hydrazine is mixed with 100.0 grams of dinitrogen tetroxide. How much nitrogen gas was produced?

9. 7.321 mg of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 17.873 mg and the amount of water produced was 7.316 mg. Determine the empirical formula of the compound.

10. 0.1101 gram of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 0.2503 gram and the amount of water produced was 0.1025 gram. A determination of the molar mass of the compound indicated a value of approximately 115 grams/mol. Determine the empirical formula and the molecular formula of the compound.

13. Sodium metal reacts vigorously with water to produce a solution of sodium hydroxide and hydrogen gas:

        $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

    What mass of hydrogen gas can be produced when 10 grams of sodium is added to 15 grams of water?

14. Nitrous oxide reacts with oxygen to produce nitrogen dioxide according to the equation:

        $2N_2O(g) + 3O_2(g) \rightarrow 4NO_2(g)$

    What mass of nitrogen dioxide can be made from 42 grams of nitrous oxide and 42 grams of oxygen?

15. If only 75 grams of nitrogen dioxide was produced in the reaction described in the previous question, what was the % yield?