Chapter 11

Summary of Terms

Anode The electrode where chemicals are oxidized.

Cathode The electrode where chemicals are reduced.

Combustion The rapid exothermic oxidation–reduction reaction between a material and molecular oxygen.

Corrosion The deterioration of a metal, typically caused by atmospheric oxygen.

Electrochemistry The study of the relationship between electrical energy and chemical change.

Electrode Any material that conducts electrons into or out of a medium in which electrochemical reactions are occurring.

Electrolysis The use of electrical energy to produce chemical change.

Half reaction One half of an oxidation–reduction reaction, represented by an equation showing electrons as either reactants or products.

Oxidation The process whereby a reactant loses one or more electrons.

Photoelectric Effect The ability of light to knock electrons away from atoms.

Reduction The process whereby a reactant gains one or more electrons.

Steel Iron strengthened by small percentages of carbon.

Review Questions

11.1 Losing and Gaining Electrons

1. Which elements have the greatest tendency to behave as oxidizing agents?

2. What elements have the greatest tendency to behave as reducing agents?

3. Write an equation for the half reaction in which a potassium atom, K, is oxidized.

4. What happens to a reducing agent as it reduces?

11.2 Harnessing the Energy

5. What is electrochemistry?

6. What is the purpose of the salt bridge in a voltaic cell?

11.3 Electricity from Batteries

7. What type of reaction occurs at the cathode?

8. What type of reaction occurs at the anode?

9. Does lithium metal accept or donate electrons in a lithium battery?

11.4 Electricity from Fuel Cells

10. What is the prime difference between a battery and a fuel cell?

11. What else do fuel cells produce besides electricity?

11.5 Energy from Photovoltaics

12. How is *p*-type silicon made?

13. What happens when a slice of *n*-type silicon is joined to a slice of *p*-type silicon?

14. Light shining on a slab of pure silicon dislodges electrons from the silicon atoms. What happens to these electrons?

11.6 Electrolysis Produces Change

15. What is electrolysis, and how does it differ from what goes on inside a battery?

16. In what year was the efficient electrolysis of aluminum discovered?

11.7 Producing Metals

17. Which group of metals requires the most energy to be recovered from metal-containing compounds?

18. When iron ions are reduced to neutral iron atoms in a blast furnace, where do the electrons come from?

19. How are copper (II) sulfide, CuS, and iron (III) oxide, Fe_2O_3, separated from each other in a blast furnace in the preparation of copper metal?

11.8 Corrosion and Combustion

20. What metal coats a galvanized nail?

21. What do the oxidation of zinc and the oxidation of aluminum have in common?

22. What are some differences between corrosion and combustion?

23. What happens to the polarity of oxygen atoms as they transform from molecular oxygen, O_2, into water molecules, H_2O?

Quantitative Questions

24. Each year about 1.6×10^7 (16 million) metric tons (mt) of aluminum are produced. How many grams is this? (Recall, 1 mt is 1000 kg.)

25. Use the following balanced chemical equation to show that the production of 1.6×10^7 metric tons of aluminum, Al, through electrolysis each year produces about 2.0×10^7 metric tons of carbon dioxide, CO_2. Interestingly, the total mass of our atmosphere is only about 5×10^{15} metric tons.

$$4\ Al_2O_3 + 3\ C \rightarrow 4\ Al + 3\ CO_2$$

Solutions (Odd-Numbered)

1. The elements in the upper right of the periodic table (except for noble gases) have the greatest tendency to behave as oxidizing agents.

3. $K \rightarrow K+ + 1e-$

5. Electrochemistry is the study of the relationship between electric energy and chemical change.

7. Reduction occurs at the cathode. Remember the "red cat."

9. The lithium donates electrons.

11. Fuel cells also produce the chemical products of the electricity generating chemical reactions. A hydrogen fuel cell, for example, produces clean water suitable for drinking.

13. Electrons migrate from *n*-type silicon to *p*-type silicon across the junction when these two slices of silicon are pressed close together.

15. Electrolysis uses electrical energy to produce a chemical change whereas a battery uses a spontaneous chemical change to produce electrical energy. Both involve oxidation-reduction reactions.

17. Metals located toward the lower left corner of the periodic table, which have the greatest tendency to lose electrons, are the most difficult to be recovered from metallic compounds.

19. Copper (II) sulfide and iron (III) oxide are mixed with limestone and sand and heated. The iron (III) oxide dissolves in the $CaSiO_3$ formed and the copper sulfide melts and goes to the bottom of the furnace where it is removed.

21. After oxidation, zinc and aluminum both form water-insoluble oxidized coats, impervious to penetration by air and moisture, that prevent further oxidation.

23. The oxygen atoms become somewhat negatively charged, which is to say they are gaining electron.

25. Use the techniques of Section 9.3 to solve for this problem. First convert metric tons of aluminum to grams of aluminum and then to moles of aluminum. Then follow the coefficients of the balanced equation to calculate the moles of carbon dioxide formed. Lastly, convert from moles of carbon dioxide to grams of carbon dioxide to metric tons of carbon dioxide:

$(1.6 \times 10^{13}$ mt Al)(1000 kg/1 mt)(1000 g/1 kg)(1 mole Al/27.0 g Al)(3 moles CO_2/4 moles Al)(44 g CO_2/1 mole CO_2)(1 kg/1000 g)(1 mt/1000 kg) $= 2.0 \times 10^{13}$ mt of CO_2.