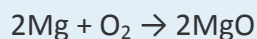## 14.5 End-of-Chapter Material

ADDITIONAL EXERCISES

1. Oxidation was once defined as chemically adding oxygen to a substance. Use this reaction to argue that this definition is consistent with the modern definition of oxidation.

$2Mg + O_2 \rightarrow 2MgO$

2. Reduction was once defined as chemically adding hydrogen to a substance. Use this reaction to argue that this definition is consistent with the modern definition of reduction.

   $C_2H_2 + 2H_2 \rightarrow C_2H_6$
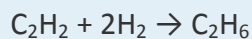
3. Assign oxidation numbers to the atoms in each substance.

   a. Kr (krypton)
   b. krypton tetrafluoride (KrF_4)
   c. dioxygen difluoride (O_2F_2)

4. Assign oxidation numbers to the atoms in each substance.

   a. lithium hydride (LiH)
   b. potassium peroxide (K_2O_2)
   c. potassium fluoride (KF)

5. N atoms can have a wide range of oxidation numbers. Assign oxidation numbers for the N atom in each compound, all of which are known compounds.

   a. N_2O_5
   b. N_2O_4
   c. NO_2
   d. NO

e. N_2H_4

f. NH_3

6. Cr atoms can have a wide range of oxidation numbers. Assign oxidation numbers for the Cr atom in each compound, all of which are known compounds.

a. Na_2CrO_4

b. $Na_2Cr_2O_7$

c. CrF_5

d. $CrCl_3$

e. $CrCl_2$

7. Balance this redox reaction by inspection.

$S_8 + O_2 \rightarrow SO_2$

8. Balance this redox reaction by inspection.

$C_{18}H_{38} + O_2 \rightarrow CO_2 + H_2O$

9. Balance this redox reaction by the half reaction method by assuming an acidic solution.

$Cr_2O_7{}^{2-} + Fe \rightarrow Cr^{3+} + Fe^{3+}$

10. Balance the redox reaction in Exercise 9 by the half reaction method by assuming a basic solution.

11. The uranyl ion ($UO_2{}^{2+}$) is a fairly stable ion of uranium that requires strong reducers to reduce the oxidation number of uranium further. Balance this

redox reaction using the half reaction method by assuming an acidic solution.

$$UO_2^{2+} + HN_3 \rightarrow U + N_2$$
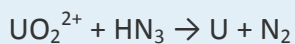
12. Balance the redox reaction in Exercise 11 by the half reaction method by assuming a basic solution.

13. Zinc metal can be dissolved by acid, which contains H^+ ions. Demonstrate that this is consistent with the fact that this reaction has a spontaneous voltage:

$$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$$

14. Copper metal cannot be dissolved by acid, which contains H^+ ions. Demonstrate that this is consistent with the fact that this reaction has a nonspontaneous voltage:

$$Cu + 2H^+ \rightarrow Cu^{2+} + H_2$$

15. A disproportionation reaction occurs when a single reactant is both oxidized and reduced. Balance and determine the voltage of this disproportionation reaction. Use the data in Table 14.1 "Standard Reduction Potentials of Half Reactions".

$$Cr^{2+} \rightarrow Cr + Cr^{3+}$$

16. A disproportionation reaction occurs when a single reactant is both oxidized and reduced. Balance and determine the voltage of this disproportionation reaction. Use the data in Table 14.1 "Standard Reduction Potentials of Half Reactions".

$$Fe^{2+} \rightarrow Fe + Fe^{3+}$$
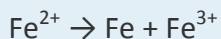
17. What would be overall reaction for a fuel cell that uses CH_4 as the fuel?

18. What would be overall reaction for a fuel cell that uses gasoline (general formula C_8H_{18}) as the fuel?

19. When NaCl undergoes electrolysis, sodium appears at the cathode. Is the definition of cathode the same for an electrolytic cell as it is for a voltaic cell?

20. When NaCl undergoes electrolysis, chlorine appears at the anode. Is the definition of anode the same for an electrolytic cell as it is for a voltaic cell?

21. An award is being plated with pure gold before it is presented to a recipient. If the area of the award is 55.0 cm^2 and will be plated with 3.00 μm of Au, what mass of Au will be plated on the award? The density of Au is 19.3 g/cm^3.

22. The unit of electrical charge is called the coulomb (C). It takes 96,500 coulombs of charge to reduce 27.0 g of Al from Al^{3+} to Al metal. At 1,040 cm^3, how many coulombs of charge were needed to reduce the aluminum in the cap of the Washington monument, assuming the cap is pure Al? The density of Al is 2.70 g/cm^3.

ANSWERS

1. As oxygen is added to magnesium, it is being oxidized. In modern terms, the Mg atoms are losing electrons and being oxidized, while the electrons are going to the O atoms.

3. a. Kr: 0

   b. Kr: +4; F: −1

   c. O: +1; F: −1

5. a. +5
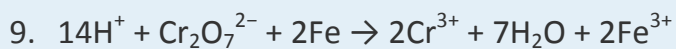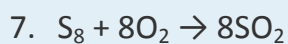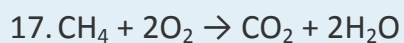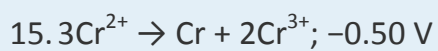
   b. +4

   c. +4

   d. +2

   e. −2

   f. −3

7. $S_8 + 8O_2 \rightarrow 8SO_2$

9. $14H^+ + Cr_2O_7^{2-} + 2Fe \rightarrow 2Cr^{3+} + 7H_2O + 2Fe^{3+}$

11. $6HN_3 + UO_2^{2+} \rightarrow U + 2H_2O + 9N_2 + 2H^+$

13. The voltage of the reaction is +0.76 V, which implies a spontaneous reaction.

15. $3Cr^{2+} \rightarrow Cr + 2Cr^{3+}$; −0.50 V

17. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

19. yes because reduction occurs at the cathode

21. 0.318 g