Chapter 6 Oxidation-Reduction Reactions

Section 6.1
1. Oxidation is defined as

> a. gain of a proton
> b. loss of a proton
> c. gain of an electron
> ! d. loss of an electron
> e. capture of an electron by a neutron

Section 6.1
2. Which one of the statements below is true concerning an oxidation-reduction reaction?

> a. the reactant which is being reduced is the reducing reagent
> ! b. the reactant which is being oxidized is the reducing reagent
> c. the reactant which gains electrons is the reducing reagent
> d. the reactant which loses electrons is the oxidizing reagent
> e. none of the statements, a—d, is true for an oxidation-reduction reaction

Section 6.1
3. What is the oxidation number of each sulfur atom in the $S_2O_8^{2-}$ ion?

> a. -2
> b. +1
> c. +3
> d. +5
> ! e. +7

Section 6.1
4. What is the oxidation number of the chlorine atom in the $HClO_4$ molecule?

> a. -1
> b. +3
> c. +5
> ! d. +7
> e. +9

Section 6.1
5. What is the oxidation number of each oxygen atom in the compound, BaO_2?

> ! a. -1
>   b. -2
>   c. +1
>   d. +2
>   e. +3

Section 6.1
6. What is the oxidation number of the potassium atom in the compound, KO_2?

>   a. -1
>   b. -1
> ! c. +1
>   d. +2
>   e. +4

Section 6.1
7. What is the oxidation number of each boron atom in the compound, $Na_2B_4O_7$?

>   a. -3
>   b. +1
>   c. +5
> ! d. +3
>   e. +6

Section 6.1
16. Which one of the following processes represents an oxidation?

>   a. $Ba^{2+}(aq) + CrO_4^{2-}(aq) \not\rightarrow BaCrO_4(s)$
>   b. $2 H^+(aq) + CO_3^{2-}(aq) \not\rightarrow H_2O(l) + CO_2(g)$
>   c. $Fe^{3+}(aq) \rightarrow Fe^{2+}(aq)$
> ! d. $MnO_2(s) \rightarrow MnO_4^-(aq)$
>   e. $2 CrO_4^{2-}(aq) + 2 H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$

Comment [RFW1]:
Comment [RFW2]:

Section 6.1
17. Which one of the following processes represents a reduction?

>   a. $Ba^{2+}(aq) + CrO_4^{2-}(aq) \not\rightarrow BaCrO_4(s)$
>   b. $2 H^+(aq) + CO_3^{2-}(aq) \not\rightarrow H_2O(l) + CO_2(g)$
> ! c. $CrO_4^{2-}(aq) \rightarrow Cr^{3+}(aq)$
>   d. $MnO_2(s) \rightarrow MnO_4^-(aq)$
>   e. $2 CrO_4^{2-}(aq) + 2 H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$

Comment [RFW3]:
Comment [RFW4]:

Section 6.1
18. Which one of the following processes represents an oxidation?

a. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

b. $2 H^+(aq) + SO_3^{2-}(aq) \rightarrow H_2O(l) + SO_2(g)$

c. $VO_4^{3-}(aq) \rightarrow VO^{2+}(aq)$

! d. $CrO_2^-(aq) \rightarrow CrO_4^{2-}(aq)$

e. $2 S_2O_7^{2-}(aq) + H_2O(l) \rightarrow 2 SO_4^{2-}(aq) + 2 H^+(aq)$

Section 6.1

19. Which one of the following processes represents a reduction?

a. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

b. $2 H^+(aq) + SO_3^{2-}(aq) \rightarrow H_2O(l) + SO_2(g)$

! c. $VO_4^{3-}(aq) \rightarrow VO^{2+}(aq)$

d. $CrO_2^-(aq) \rightarrow CrO_4^{2-}(aq)$

e. $2 S_2O_7^{2-}(aq) + H_2O(l) \rightarrow 2 SO_4^{2-}(aq) + 2 H^+(aq)$

Section 6.1
20. What is the change in oxidation number of each chromium atom in the process,
$$K_2Cr_2O_7 \rightarrow Cr_2(SO_4)_3$$
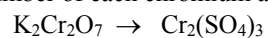
    a. -1
    b. -6
    c. +3
 ! d. -3
    e. +6

Section 6.1
22. What is the change in oxidation number of each nitrogen atom in the process,
$$HNO_3 \rightarrow NO$$
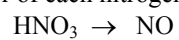
    a. +3
    b. -6
    c. -1
 ! d. -3
    e. +5

Section 6.1
23. What is the change in oxidation number of each manganese atom in the process,
$$KMnO_4 \rightarrow MnSO_4$$
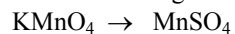
    a. +3
    b. -3
    c. -6
 ! d. -5
    e. +1

Section 6.2

33. Balance the half reaction, $Cl_2O_7(g) \rightarrow HClO(aq)$, taking place in acidic media. Which answer below describes how many electrons are needed to balance the half reaction?

    a. 2 electrons, left side
    b. 3 electrons, right side
 ! c. 12 electrons, left side
    d. 6 electrons, right side
    e. 8 electrons, left side

Section 6.2

34. Balance the half reaction, $C_5O_5^{2-}(g) \rightarrow CO_3^{2-}(aq)$, taking place in basic media. Which answer below describes how many hydroxide ions are needed to balance the half reaction?

    a. 8 ions, left side
    b. 12 ions, right side
    c. 12 ions, left side
 ! d. 20 ions, left side
    e. 20 ions, right side

Section 6.2

35. Balance the half reaction, $C_5O_5^{2-}(g) \rightarrow CO_3^{2-}(aq)$, taking place in basic media. Which answer below describes how many electrons are needed to balance the half reaction?

    a. 4 electrons, left side
    b. 8 electrons, right side
    c. 8 electrons, left side
    d. 12 electrons, left side
 ! e. 12 electrons, right side

Section 6.2

37. Balance the half reaction, $C_8H_{10}(l) \rightarrow C_8H_4O_4^{2-}(aq)$, taking place in basic media. Which answer below describes how many electrons are needed to balance the half reaction?

      a. 4 electrons, left side
      b. 8 electrons, right side
      c. 8 electrons, left side
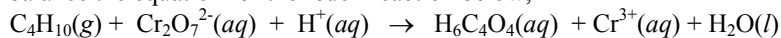   d. 12 electrons, left side
 !   e. 12 electrons, right side

Section 6.2

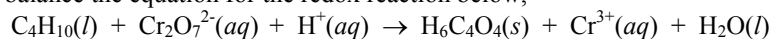38. When you balance the equation for the redox reaction below,
$$C_4H_{10}(g) + Cr_2O_7^{2-}(aq) + H^+(aq) \rightarrow H_6C_4O_4(aq) + Cr^{3+}(aq) + H_2O(l)$$
the reducing agent is

 !   a. $C_4H_{10}(g)$
      b. $Cr_2O_7^{2-}(aq)$
      c. $H^+(aq)$
      d. $H_6C_4O_4(aq)$
      e. $Cr^{3+}(aq)$

Section 6.2

39. When you balance the equation for the redox reaction below,
$$C_4H_{10}(l) + Cr_2O_7^{2-}(aq) + H^+(aq) \rightarrow H_6C_4O_4(s) + Cr^{3+}(aq) + H_2O(l)$$
the oxidizing agent is

      a. $C_4H_{10}(l)$
 !   b. $Cr_2O_7^{2-}(aq)$
      c. $H^+(aq)$
      d. $H_6C_4O_4(s)$
      e. $Cr^{3+}(aq)$

41. When you balance the equation for the redox reaction below,
$$VO_4^{3-}(aq) + SO_2(g) + 2\,H^+(aq) \rightarrow VO^{2+}(aq) + SO_4^{2-}(aq) + H_2O(l)$$
the oxidizing agent is
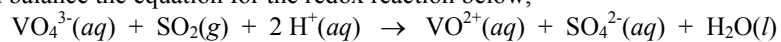
  ! a. $VO_4^{3-}(aq)$
    b. $VO^{2+}(aq)$
    c. $H^+(aq)$
    d. $SO_2(g)$
    e. $SO_4^{2-}(aq)$

Section 6.2
43. Complete the balancing of the following half reaction, taking place in basic media,
$$Br^-(aq) \rightarrow BrO_3^-(aq)$$
Which answer below describes how many electrons are needed to balance the half reaction?
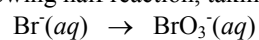
    a. 2 electrons, left side
    b. 2 electrons, right side
    c. 4 electrons, right side
  ! d. 6 electrons, right side
    e. 6 electrons, left side

Section 6.3

58. In a chemical reaction, magnesium metal reacts with aqueous sulfuric acid solution to produce magnesium sulfate (in solution) and hydrogen gas. In the course of the reaction, which element undergoes an increase in oxidation number?

       a. hydrogen, only
!   b. magnesium, only
       c. oxygen, only
       d. sulfur, only
       e. magnesium and hydrogen

Section 6.3

59. In a series of chemical test reactions the following observations were made when some metallic element samples were treated with 3.00 molar hydrochloric acid solution. Zn: metal dissolves, hydrogen gas is emitted. Cu: no reaction. Ag: no reaction. Mg: metal dissolves, hydrogen gas is emitted. Mn: metal dissolves, hydrogen gas is emitted. Which statement below is true?

       a. Mg, Mn, Zn are more reactive than Ag, Cu; but less reactive than H_2.
       b. Mg, Mn, Zn are less reactive than Ag, Cu; but more reactive than H_2.
!   c. Mg, Mn, Zn are more reactive than Ag, Cu; and more reactive than H_2.
       d. Mg, Mn, Zn are less reactive than Ag, Cu; and less reactive than H_2.
       e. These observations are insufficient to form any judgment about relative reactivity of any of the elements listed above.

Section 6.3
61. Three metallic elements, copper, gold and zinc, can be distinguished from one another on the basis of how they react with two strong acids, $HNO_3(aq)$ and $HCl(aq)$ Which set below, using the abbreviations R (for reaction occurs) and NR (for no reaction) correctly describes what occurs?

   a. Au: HCl(R), HNO$_3$(NR)   Cu: HCl(R), HNO$_3$(NR)   Zn: HCl(R), HNO$_3$(NR)
   b. Au: HCl(NR), HNO$_3$(NR)   Cu: HCl(R), HNO$_3$(R)   Zn: HCl(R), HNO$_3$(NR)
   ! c. Au: HCl(NR), HNO$_3$(NR)   Cu: HCl(NR), HNO$_3$(R)   Zn: HCl(R), HNO$_3$(R)
   d. Au: HCl(NR), HNO$_3$(NR)   Cu: HCl(R), HNO$_3$(R)   Zn: HCl(NR), HNO$_3$(R)
   e. Au: HCl(NR), HNO$_3$(NR)   Cu: HCl(R), HNO$_3$(NR)   Zn: HCl(R), HNO$_3$(R)

Section 6.4
65. In terms of activity, the series in increasing order for metals is found to be,
$$Au < Ag < Cu < Sn < Cd < Zn < Al < Mg < Na < Cs$$
   Which reaction below ***does not occur spontaneously*** upon mixing the reagents shown?

   ! a. $Cd(s) + Al^{3+}(aq) \rightarrow Cd^{2+}(aq) + Al(s)$
   b. $Cd(s) + Cu^{2+}(aq) \rightarrow Cd^{2+}(aq) + Cu(s)$
   c. $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
   d. $Al(s) + Ag^{+}(aq) \rightarrow Al^{3+}(aq) + Ag(s)$
   e. $Cu(s) + Au^{3+}(aq) \rightarrow Cu^{2+}(aq) + Au(s)$

Section 6.4
66. In terms of activity, the series in increasing order for metals is found to be,
$$Au < Ag < Cu < Sn < Cd < Zn < Al < Mg < Na < Cs$$
   Which reaction below ***occurs spontaneously*** upon mixing the reagents shown?

   a. $Sn(s) + Zn^{2+}(aq) \rightarrow Sn^{2+}(aq) + Zn(s)$
   b. $Ag(s) + Mg^{2+}(aq) \rightarrow Ag^{+}(aq) + Mg(s)$
   ! c. $Zn(s) + Au^{3+}(aq) \rightarrow Zn^{2+}(aq) + Au(s)$
   d. $Ag(s) + Mn^{2+}(aq) \rightarrow Ag^{+}(aq) + Mn(s)$
   e. $Sn(s) + Al^{3+}(aq) \rightarrow Sn^{2+}(aq) + Al(s)$

Section 6.4
67. In terms of activity, the series in increasing order for metals is found to be,
$$Au < Ag < Cu < Sn < Cd < Zn < Al < Mg < Na < Cs$$
   Based on this list, which one of the elements presented below would undergo oxidation most readily?

   a. Ag
   ! b. Al
   c. Cu
   d. Cd
   e. Zn

Section 6.5
74. When the hydrocarbon, C_8H_{16}, undergoes complete combustion, which is an oxidation-reduction reaction, a specific set of products are formed. If you write the equation for the reaction and balance it, the sum of the coefficients for the reagents in the balanced equation will be

       a. 17
       b. 19
       c. 21
       d. 26
  ! e. 29

Section 6.5
76. When the carbohydrate, $C_{12}H_{22}O_{11}$, undergoes complete combustion, the reducing agent in the reaction is

       a. oxygen
  ! b. the carbohydrate
       c. hydrogen
       d. carbon
       e. carbon dioxide

Section 6.6
77. Iron in a sample with non-interfering substances can be determined by a titration using dichromate ion in acidic solution. The iron is converted to $Fe^{2+}(aq)$ ions which are then titrated by the dichromate ion. The reaction is:

        $6\ Fe^{2+}(aq) + 1\ Cr_2O_7^{2-}(aq) + \underline{\ \ \ \ } \rightarrow 6\ Fe^{3+}(aq) + \underline{\ \ } Cr^{3+}(aq) + \underline{\ \ \ \ }$
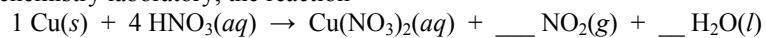
How many grams of iron are there present in a sample if it required 42.7 mL of 0.0180 molar $Na_2Cr_2O_7(aq)$ solution for the titration described by the incomplete equation above?

       a. 0.043 g
  ! b. 0.258 g
       c. 3.61 g
       d. 7.07 g
       e. 7.15 g

Section 6.6

78. In general chemistry laboratory, the reaction

$$1\ Cu(s)\ +\ 4\ HNO_3(aq)\ \rightarrow\ Cu(NO_3)_2(aq)\ +\ \underline{\quad}\ NO_2(g)\ +\ \underline{\quad}\ H_2O(l)$$

is used to dissolve the copper metal. If a 1.000 g sample of copper is used, and instructions say to use **four** times as much acid as the calculated amount, how many mL (to the nearest ml) of 15.0 M nitric acid would be used in the procedure for this sample?

      a. 4 ml
      b. 5 ml
      c. 10 ml
 ! d. 17 ml
      e. 25 ml

Section 6.6

81. Zinc reacts with permanganate ion to form $Zn^{2+}(aq)$ ions and $Mn^{2+}(aq)$ ions . The reaction is:

__ $Zn(s)$ + 2 $MnO_4^-(aq)$ + ____ → __ $Zn^{2+}(aq)$ + __ $Mn^{2+}(aq)$ + ____
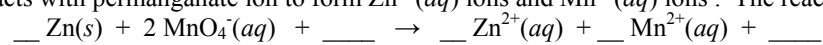
How many grams of zinc are required to completely react with 100.0 mL of a 0.0150 molar solution of $KMnO_4(aq)$?

      a. 0.0392 g
      b. 0.0981 g
  ! c. 0.245 g
      d. 10.2 g
      e. 43.9 g

Section 6.1
83. Is the process, $Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq)$ an oxidation or a reduction? _____ (! reduction)

Section 6.1
84. Is the process, $NO_3^-(aq) \rightarrow NO(g)$ an oxidation or a reduction? _____ (! reduction)
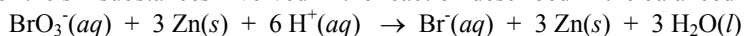
Section 6.1
85. Is the process, $S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq)$ an oxidation or a reduction? _____ (! oxidation)

Section 6.1
86. Is the process, $C_2O_4^{2-}(aq) \rightarrow CO_3^{2-}(aq)$ an oxidation or a reduction? _____ (! oxidation)

Section 6.1
87. Which one of the six substances involved in the reaction described in the balanced equation,
$$BrO_3^-(aq) + 3\ Zn(s) + 6\ H^+(aq) \rightarrow Br^-(aq) + 3\ Zn(s) + 3\ H_2O(l)$$
is the oxidizing agent? _____ (! $BrO_3^-(aq)$)

Section 6.1
88. Which one of the six substances involved in the reaction described in the balanced equation,
$$5\ H_2O(l) + 4\ Cl_2(g) + S_2O_3^{2-}(aq) \rightarrow 2\ SO_4^{2-}(aq) + 8\ Cl^-(aq) + 10\ H^+(aq)$$
is the reducing agent? _____ (! $S_2O_3^{2-}(aq)$)
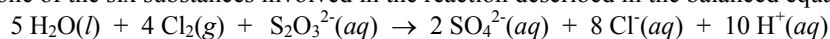
Section 6.1
89. Which one of the six substances involved in the reaction described just below is the reducing agent?
$$C_6H_{12}O_6(aq) + NO_3^-(aq) + H^+(aq) \rightarrow C_6H_{10}O_6(aq) + NO_2(g) + H_2O(l)$$
_____ (! $C_6H_{12}O_6(aq)$)
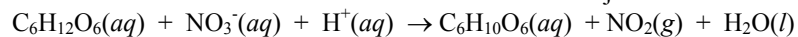
Section 6.2
90. When the equation, $Al(s) + NO_3^-(aq) \rightarrow NO(g) + Al^{3+}(aq)$ is balanced, the Al/NO_3^- ratio is _____ (! 1:1)

Section 6.2

91. When the equation, $Zn(s) + NO_3^-(aq) \rightarrow NH_4^+(aq) + Zn^{2+}(aq)$ is balanced, the Zn/NO_3^- ratio is
_____ (! 4:1)

Section 6.3

92. When a metal displaces hydrogen from a non-oxidizing strong acid, which substance is the
oxidizing agent? _____ (! the H^+ ion)

Section 6.3

93. When a metal displaces hydrogen from a non-oxidizing strong acid, which substance is the reducing
agent? _____ (! the metal itself)

Section 6.6

108. A solution was made by taking 2.500g of $KMnO_4$ and dissolving it in enough water to make 1.000
liter of solution. This solution was used to titrate $H_2C_2O_4 \cdot 2H_2O$, a very pure substance. In acidic
media, the reaction is

$$MnO_4^-(aq) + H_2C_2O_4(aq) + \_\_\_ \rightarrow CO_2(g) + Mn^{2+}(aq) + \_\_\_$$

How many mL of this solution are required to titrate a 0.480 g sample of $H_2C_2O_4 \cdot 2H_2O$? _____
(! 96.3 ml)

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