185

2. The atomic mass of rhenium is 186.2. Given that 37.1% of natural rhenium is rhenium-~~85~~, what is the other stable isotope?

   a) $^{183}_{75}Re$
   b) $^{187}_{75}Re$
   c) $^{189}_{75}Re$
   d) $^{181}_{75}Re$
   e) $^{190}_{75}Re$

   ANS: b) $^{187}_{75}Re$

3. Consider the element indium, atomic number 49, atomic mass 114.8 g. The nucleus of an atom of indium-112 contains

   a) 49 protons, 63 neutrons, 49 electrons.
   b) 49 protons, 49 neutrons.
   c) 49 protons, 49 alpha particles.
   d) 49 protons, 63 neutrons.
   e) 49 protons, 112 neutrons.

   ANS: d) 49 protons, 63 neutrons.

4. Gallium consists of two isotopes of masses 68.95 amu and 70.95 amu with abundances of 60.16% and 39.84%, respectively. What is the average atomic mass of gallium?

   a) 69.95
   b) 70.15
   c) 71.95
   d) 69.75
   e) 69.55

   ANS: d) 69.75

16. A given sample of xenon fluoride contains molecules of a single type XeF_n, where n is some whole number. Given that 9.03×10^{20} molecules of XeF_n weigh 0.311 g, calculate n.

   a) 1
   b) 2
   c) 4
   d) none of these

   ANS: c) 4

24. Which compound contains the highest percent by mass of hydrogen?

a) HCl
b) H_2O
c) H_2SO_4
d) H_2S
e) HF

ANS: b) H_2O

32. You take an aspirin tablet (a compound consisting solely of carbon, hydrogen, and oxygen) with a mass of 1.00 g, burn it in air, and collect 2.20 g of carbon dioxide and 0.400 g water. The molar mass of aspirin is between 170 and 190 g/mol. The molecular form of aspirin is

a) $C_6H_8O_5$
b) $C_9H_8O_4$
c) $C_8H_{10}O_5$
d) $C_{10}H_6O_4$
e) none of these

ANS: b) $C_9H_8O_4$

52. The empirical formula of styrene is CH; its molar mass is 104.1. What is the molecular formula of styrene?

a) C_2H_4
b) C_8H_8
c) $C_{10}H_{12}$
d) C_6H_6
e) none of these

ANS: b) C_8H_8

6. What volume of 12.0 M nitric acid is required to prepare 6.00 L of 0.100 M nitric acid?

a) 1.20 L
b) 1.00 L
c) 0.500 L
d) 0.0500 L
e) 0.0200 L

ANS: d) 0.0500 L

97–99. Ascorbic acid, or vitamin C ($C_6H_8O_6$), is an essential vitamin. It cannot be stored in the body and must be present in the diet. Vitamin C tablets are often taken as a dietary supplement. A typical tablet contains 500.0 mg of vitamin C.

97. Determine the molar mass of vitamin C.

ANS: 176.1 g/mol

98. Determine the number of moles of vitamin C per tablet.

ANS: 2.839×10^{-3} mol/tablet

99. Determine the number of molecules of vitamin C in the tablet.

ANS: 1.710×10^{21} molecules/tablet

100. One of the major commercial uses of sulfuric acid is in the production of phosphoric acid and calcium sulfate. The phosphoric acid is used for fertilizer. The reaction is $Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$. What mass of concentrated H_2SO_4 (98% by mass) must be used to react completely with 100.00 g of calcium phosphate?

ANS: 96.770 g H_2SO_4

17. Which of the following is *not* a strong base?

a) $Ca(OH)_2$
b) KOH
c) NH_3
d) LiOH
e) $Sr(OH)_2$

ANS: c) NH_3

23. When solutions of cobalt(II) chloride and carbonic acid react, which of the following terms will be present in the net ionic equation?

a) $CoCO_3(s)$
b) $H^+(aq)$
c) $2CoCO_3(s)$
d) $2Cl^-(aq)$
e) two of these

ANS: a) $CoCO_3(s)$

How many of the following salts are expected to be insoluble in water?

sodium sulfide	barium nitrate
ammonium sulfate	potassium phosphate

a) none
b) 1
c) 2
d) 3
e) 4

ANS: a) none

56. A 0.307-g sample of an unknown triprotic acid is titrated to the third equivalence point using 35.2 mL of 0.106 M NaOH. Calculate the molar mass of the acid.

a) 247 g/mol
b) 171 g/mol
c) 165 g/mol
d) 151 g/mol
e) 82.7 g/mol

ANS: a) 247 g/mol

62. All of the following reactions

$$2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$$

$$2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$$

$$CH_4(l) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

can be classified as

a) oxidation-reduction reactions.
b) combustion reactions.
c) precipitation reactions.
d) a and b
e) a and c

ANS: a) oxidation-reduction reactions.

64. In the reaction $2Cs(s) + Cl_2(g) \rightarrow 2CsCl(s)$, Cl_2 is

a) the reducing agent.
b) the oxidizing agent.
c) oxidized.
d) the electron donor.
e) two of these

ANS: b) the oxidizing agent.

77. Given the following reaction in acidic media:

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

answer the following question: The coefficient for water in the balanced reaction is

a) 1.
b) 3.
c) 5.
d) 7.
e) none of these

ANS: d) 7

78. Balance the following oxidation-reduction reaction using the half-reaction method:

$$Fe^{3+} + I^- \rightarrow Fe^{2+} + I_2$$

In the balanced equation, the coefficient of Fe^{2+} is

a) 1.
b) 2.
c) 3.
d) 4.
e) none of these

ANS: b) 2

16. The valve between a 5-L tank containing a gas at 9 atm and a 10-L tank containing a gas at 6 atm is opened. Calculate the final pressure in the tanks.

a) 3 atm
b) 4 atm
c) 7 atm
d) 15 atm
e) none of these

ANS: c) 7 atm

35. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is correct? (Assume all gases obey the ideal gas law.)

a) If the temperature of the cylinder is changed from 25°C to 50°C, the pressure inside the cylinder will double.
b) If a second mole of argon is added to the cylinder, the ratio T/P would remain constant.
c) A cylinder of identical volume filled with the same *pressure* of helium must contain more atoms of gas because He has a smaller atomic radius than argon.
d) Two of the above.
e) None of the above.

ANS: e) None of the above.

36–41. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure.

36. Which gas has the highest density?

a) He
b) Cl_2
c) CH_4
d) NH_3
e) all gases the same

ANS: b) Cl_2

37. For which gas do the molecules have the highest average velocity?

a) He
b) Cl_2
c) CH_4
d) NH_3
e) all gases the same

ANS: a) He

73. Oxygen gas, generated by the reaction $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$, is collected over water at 27°C in a 2.00-L vessel at a total pressure of 760. torr. (The vapor pressure of H_2O at 27°C is 26.0 torr.) How many moles of $KClO_3$ were consumed in the reaction?

a) 0.0790 moles
b) 0.119 moles
c) 0.0527 moles
d) 0.0813 moles
e) none of these

ANS: c) 0.0527 moles

90. Order the following in increasing rate of effusion:

$F_2, Cl_2, NO, NO_2, CH_4$

a) $Cl_2 < NO_2 < F_2 < NO < CH_4$
b) $Cl_2 < F_2 < NO_2 < CH_4 < NO$
c) $CH_4 < NO_2 < NO < F_2 < Cl_2$
d) $CH_4 < NO < F_2 < NO_2 < Cl_2$
e) $F_2 < NO < Cl_2 < NO_2 < CH_4$

ANS: a) $Cl_2 < NO_2 < F_2 < NO < CH_4$

88. Which of the following properties of a real gas is related to the *b* coefficient in the van der Waals equation?

a) Real gases consist of molecules or atoms that have volume.
b) The average speed of the molecules of a real gas increases with temperature.
c) There are attractive forces between atoms or molecules of a real gas.
d) The rate of effusion of a gas is inversely proportional to the square root of the molecular weight of the gas.

ANS: a) Real gases consist of molecules or atoms that have volume.

Consider the chemical system $CO + Cl_2 \leftrightarrow COCl_2$; $K = 4.6 \times 10^9$ L/mol.

7. How do the equilibrium concentrations of the reactants compare to the equilibrium concentration of the product?

a) They are much smaller.
b) They are much bigger.
c) They are about the same.
d) They have to be exactly equal.
e) You can't tell from the information given.

ANS: a) They are much smaller.

8. If the concentration of the product were to double, what would happen to the equilibrium constant?

a) It would double its value.
b) It would become half its current value.
c) It would quadruple its value.
d) It would not change its value.
e) It would depend on the initial conditions of the product.

ANS: d) It would not change its value.

18. For the reaction

$$3H_2(g) + N_2(g) \leftrightharpoons 2NH_3(g)$$

the relationship between K and K_p at a given temperature T is:

a) $K = K_p$
b) $K_p = K(RT)^2$
c) $K = K_p(RT)^2$
d) $K = \sqrt{K_p}$
e) none of these

ANS: c) $K = K_p(RT)^2$

19. For the reaction below, $K_p = 1.16$ atm at 800°C.

$$CaCO_3(s) \leftrightharpoons CaO(s) + CO_2(g)$$

If a 20.0-gram sample of $CaCO_3$ is put into a 10.0-liter container and heated to 800°C, what percent of the $CaCO_3$ will react to reach equilibrium?

a) 14.6%
b) 65.9%
c) 34.1%
d) 100.0%
e) none of these

ANS: b) 65.9%

30. At a certain temperature K for the reaction

$$2NO_2 \leftrightharpoons N_2O_4$$

is 7.5 liters/mole. If 2.0 moles of NO_2 are placed in a 2.0-liter container and permitted to react at this temperature, calculate the concentration of N_2O_4 at equilibrium.

a) 0.39 moles/liter
b) 0.65 moles/liter
c) 0.82 moles/liter
d) 7.5 moles/liter
e) none of these

ANS: a) 0.39 moles/liter

50–52. The following questions refer to a system of four gases (each initially 2 mol samples) combined in a 2-liter bottle. The equilibrium is shown here:

$$A + B \leftrightarrow C + D \qquad (K = 2.6)$$

50. Which of the following statements is correct?

a) The system is in equilibrium with the initial concentrations.
b) The equilibrium lies to the left.
c) The concentration of the reactants and the products will be equal at equilibrium.
d) The equilibrium lies to the right.
e) The initial concentrations of the products do not equal the initial concentrations of the reactants.

ANS: d) The equilibrium lies to the right.

51. What is the equilibrium concentration of gas A?

a) 2.5 M
b) 0.2 M
c) 1.2 M
d) 0.8 M
e) 1.6 M

ANS: d) 0.8 M

67–72. Given the equation $2A(g) \leftrightarrow 2B(g) + C(g)$. At a particular temperature, $K = 1.6 \times 10^{4}$.

67. If you start with 2.0 M of chemical A, calculate the equilibrium concentration of chemical C.

a) 8.3×10^{-3} M
b) 6.25×10^{-5} M
c) 2.0 M
d) 0.99 M
e) none of these

ANS: d) 0.99 M

8. At 0°C, the ion-product constant of water, K_w, is 1.2×10^{-15}. The pH of pure water at 0°C is:

a) 7.00
b) 6.88
c) 7.56
d) 7.46
e) none of these

ANS: d) 7.46

10. Given the following acids and *Ka* values:

$HClO_4$	HOAc	HCN	HF
1×10^{7}	1.76×10^{-5}	4.93×10^{-10}	3.53×10^{-4}

which shows the conjugate bases listed by increasing strength?

a) $CN^-, F^-, OAc^-, ClO_4^-$
b) $CN^-, OAc^-, F^-, ClO_4^-$
c) $CN^-, ClO_4^-, F^-, OAc^-$
d) $ClO_4^-, OAc^-, CN^-, F^-$
e) $ClO_4^-, F^-, OAc^-, CN^-$

ANS: e) $ClO_4^-, F^-, OAc^-, CN^-$

28. Calculate the pH of a 10.0 M solution of HNO_3.

a) 10
b) 1.0
c) 0
d) –1.0
e) none of these

ANS: d) –1.0

45. If an acid, HA, is 10.0% dissociated in a 1.0 M solution, what is the K_a for this acid?

a) 9.1×10^{-2}
b) 1.1×10^{-2}
c) 8.1×10^{-1}
d) 6.3×10^{-2}
e) none of these

ANS: b) 1.1×10^{-2}

46. Calculate the pH of a 0.10 M solution of HOCl, $K_a = 3.5 \times 10^{-8}$.

a) 4.23
b) 8.46
c) 3.73
d) 1.00
e) 3.23

ANS: a) 4.23

58. Calculate the pH of a 0.10 M solution of $Ca(OH)_2$.

a) 13.30
b) 13.00
c) 0.20
d) 0.10
e) none of these

ANS: a) 13.30

97. Calculate the pH of a 0.30 M solution of NH_4Cl. (K_b for $NH_3 = 1.8 \times 10^{-5}$)

a) 3.33
b) 4.89
c) 9.11
d) 7.00
e) 11.67

ANS: b) 4.89

112. The pH of a 1.0 M sodium acetate solution is:

a) 7.0
b) greater than 7.0
c) less than 7.0
d) not enough information is given

ANS: b) greater than 7.0

9. Calculate the $[H^+]$ in a solution that is 0.10 M in NaF and 0.20 in HF. ($K_a = 7.2 \times 10^{-4}$)

a) 0.20 M
b) 7.0×10^{-4} M
c) 1.4×10^{-3} M
d) 3.5×10^{-4} M
e) none of these

ANS: c) 1.4×10^{-3} M

10. Which of the following will not produce a buffered solution?

a) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M HCl
b) 100 mL of 0.1 M $NaHCO_3$ and 25 mL of 0.2 M HCl
c) 100 mL of 0.1 M Na_2CO_3 and 75 mL of 0.2 M HCl
d) 50 mL of 0.2 M Na_2CO_3 and 5 mL of 1.0 M HCl
e) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH

ANS: e) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH

12. Calculate the pH of a solution that is 0.2 M in acetic acid ($K_a = 1.8 \times 10^{-5}$) and 0.2 M in sodium acetate.

a) 4.7
b) 9.3
c) 7.0
d) 5.4
e) 8.6

ANS: a) 4.7

21. For ammonia, K_b is 1.8×10^{-5}. To make a buffered solution of pH 10.0, the ratio of NH_4Cl to NH_3 must be:

a) 1.8 : 1
b) 1: 1.8
c) 0.18 : 1
d) 1 : 0.18
e) none of these

ANS: c) 0.18 : 1

PAGE: 15.2

22. A solution contains 0.500 M HA ($K_a = 1.0 \times 10^{-8}$) and 0.250 M NaA. What is the $[H^+]$ after 0.10 mole of HCl(g) is added to 1.00 L of this solution?

a) 1.4×10^{-8} M
b) 2.0×10^{-8} M
c) 2.5×10^{-9} M
d) 4.0×10^{-8} M
e) none of these

ANS: d) 4.0×10^{-8} M

39. Consider the titration of 100.0 mL of 0.100 M NaOH with 1.00 M HCl. How many milliliters of 1.00 M HCl must be added to reach a pH of 12.000?

a) 10.0 mL
b) 9.52 mL
c) 10.5 mL
d) 8.91 mL
e) none of these

ANS: d) 8.91 mL

71. Calculate the pH at the equivalence point for the titration of 1.0 M ethylamine, $C_2H_5NH_2$, by 1.0 M perchloric acid, $HClO_4$. (pK_b for $C_2H_5NH_2 = 3.25$)

a) 6.05
b) 2.24
c) 5.53
d) 2.09
e) 5.38

ANS: c) 5.53

107. The solubility of mol/L of Ag_2CrO_4 is 1.3×10^{-4} M at 25°C. Calculate the K_{sp} for this compound.

a) 8.8×10^{-3}
b) 6.1×10^{-9}
c) 8.8×10^{-12}
d) 4.7×10^{-13}
e) 2.3×10^{-13}

ANS: c) 8.8×10^{-12}

108. Calculate the concentration of Al^{3+} in a saturated aqueous solution of $Al(OH)_3$ ($K_{sp} = 2 \times 10^{-32}$) at 25°C.

a) 3×10^{-9}
b) 7×10^{-9}
c) 2×10^{-11}
d) 3×10^{-17}
e) none of these

ANS: e) none of these

116. Which of the following salts shows the lowest solubility in water? (K_{sp} values: $Ag_2S = 1.6 \times 10^{-49}$; $Bi_2S_3 = 1.0 \times 10^{-72}$; $HgS = 1.6 \times 10^{-54}$; $Mg(OH)_2 = 8.9 \times 10^{-12}$; $MnS = 2.3 \times 10^{-13}$)

a) Bi_2S_3
b) Ag_2S
c) MnS
d) HgS
e) $Mg(OH)_2$

ANS: d) HgS

133–136. The following questions refer to the following system: 3.5×10^2 mL of 3.2 M $Pb(NO_3)_2$ and 2.0×10^2 mL of 0.020 M NaCl are added together. K_{sp} for the lead chloride is 1.6×10^{-5}.

134. Will precipitation occur?

a) Yes
b) No
c) Maybe, it depends on the temperature.
d) Maybe, it depends on the limiting reagent concentration.
e) None of these.

ANS: a) Yes

14. When the equation for the following reaction in basic solution is balanced, what is the sum of the coefficients?

$$MnO_4^-(aq) + CN^-(aq) \rightarrow MnO_2(s) + CNO^-(aq)$$

a) 13
b) 8
c) 10
d) 20
e) 11

ANS: a) 13 **PAGE:** 17.1

15. The following two half-reactions are involved in a galvanic cell. At standard conditions, what species are produced at each electrode?

	Stand. Reduction Potential
$Ag^+ + e^- \rightarrow Ag$	0.80 V
$Ni^{2+} + 2e^- \rightarrow Ni$	–0.23 V

a) Ag is produced at the cathode and Ni at the anode.
b) Ag is produced at the cathode and Ni^{2+} at the anode.
c) Ag^+ is produced at the anode and Ni at the cathode.
d) Ag^+ is produced at the anode and Ni^{2+} at the cathode.
e) None of these is correct.

ANS: b) Ag is produced at the cathode and Ni^{2+} at the anode. **PAGE:** 17.2

16. Given the standard potential for the reaction of hydrogen and oxygen:

$$2H_2 + O_2 \rightarrow 2H_2O \qquad E° = +1.23\ V$$

calculate the standard potential for the following reaction:

$$H_2O \rightarrow H_2 + (1/2)O_2$$

a) 1.23 V
b) 0.625 V
c) –0.625 V
d) –1.23 V
e) –2.46 V

ANS: d) –1.23 V **PAGE:** 17.2

71. If you could increase the concentration of Ni^{2+}, which of the following is true about the cell potential?

a) It would increase.
b) It would decrease.
c) It would remain constant.
d) Cannot be determined.

ANS: a) It would increase. **PAGE:** 17.4

72–73. A common car battery consists of six identical cells each of which carries out the reaction

$$Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$$

72. The value of $E°$ for such a cell is 2.04 V. Calculate $\Delta G°$ at 25°C for the reaction.

a) –787 kJ
b) –98 kJ
c) –394 kJ
d) –197 kJ
e) –0.121 kJ

ANS: c) –394 kJ **PAGE:** 17.3

73. Suppose that in starting a car on a cold morning a current of 125 amperes is drawn for 15.0 seconds from a cell of the type described above. How many grams of Pb would be consumed? (The atomic weight of Pb is 207.19.)

a) 8.05
b) 2.01
c) 0.0180
d) 0.0360
e) 4.02

ANS: b) 2.01 **PAGE:** 17.7

74. A galvanic cell is constructed with copper electrodes and Cu^{2+} in each compartment. In one compartment, the $[Cu^{2+}] = 1.0 \times 10^{-3}$ M and in the other compartment, the $[Cu^{2+}] = 2.0$ M. Calculate the potential for this cell at 25°C. The standard reduction potential for Cu^{2+} is +0.34 V.

a) 0.44 V
b) –0.44 V
c) 0.098 V
d) –0.098 V
e) 0.78 V

ANS: c) 0.098 V **PAGE:** 17.4

85. If a constant current of 5.0 amperes is passed through a cell containing Cr^{3+} for 1.0 hour, how many grams of Cr will plate out onto the cathode? (The atomic mass of Cr is 51.996.)

a) 0.054 g
b) 9.7 g
c) 3.2 g
d) 1.5 g
e) 93 g

ANS: c) 3.2 g **PAGE:** 17.7

86. If an electrolysis plant operates its electrolytic cells at a total current of 1.0×10^6 amp, how long will it take to produce one metric ton (one million grams) of Mg(s) from seawater containing Mg^{2+}? (1 faraday = 96,485 coulombs)

a) 2.2 h
b) 2.4 days
c) 55 min
d) 3.7 h
e) 1 year

ANS: a) 2.2 h **PAGE:** 17.7

87. Nickel is electroplated from a $NiSO_4$ solution. A constant current of 5.00 amp is applied by an external power supply. How long will it take to deposit 100. g of Ni? The atomic mass of Ni is 58.69.

a) 18.3 h
b) 2.40 days
c) 63.1 min
d) 56.7 s
e) 1.20 s

ANS: a) 18.3 h **PAGE:** 17.7

88. Which type of battery has been designed for use in space vehicles?

a) lead storage
b) alkaline dry cell
c) mercury cells
d) fuel cells
e) silver cells

ANS: d) fuel cells **PAGE:** 17.5