


Appendix IV Answers to In-Chapter Practice Problems

Chapter E

E.1. 

- a. 29.8 °C
- b. -302.9 K


E.2.  The thermometer shown has markings every 1 °F; thus, the first digit of uncertainty is 0.1. The answer is 103.4 °F.

E.3. 

- a. Each figure in this number is significant by rule 1: three significant figures.
- b. This is a defined quantity that has an unlimited number of significant figures.
- c. Both 1's are significant (rule 1), and the interior zero is significant as well (rule 2): three significant figures.
- d. Only the two 9's are significant; the leading zeroes are not (rule 3): two significant figures.
- e. There are five significant figures because the 1, 4, and 5 are nonzero (rule 1) and the trailing zeroes are after a decimal point, so they are significant as well (rule 4).
- f. The number of significant figures is ambiguous because the trailing zeroes occur before an implied decimal point (rule 4). Assume two significant figures.

E.4.2. 

- a. 0.381
- b. 121.0
- c. 1.174
- d. 8


E.5.  21.4 g/cm³ This matches the density of platinum.

E.5.  **For More Practice**

4.50 g/cm³ The metal is titanium.


E.6.  3.15 yd

E.7.  2.445 gal

E.8.  1.61×10^6 cm³

E.8.  **For More Practice**


3.23×10^3 kg

E.9.  1.03 kg


E.9.  **For More Practice**

2.9×10^{-2} cm³

E.10.  0.855 cm

E.11.  2.70 g/cm³

Chapter 1

1.1.  For the first sample:

$$\frac{\text{mass of oxygen}}{\text{mass of carbon}} = \frac{17.2 \text{ g O}}{12.9 \text{ g C}} = 1.33 \text{ or } 1.33 : 1$$

For the second sample:

$$\frac{\text{mass of oxygen}}{\text{mass of carbon}} = \frac{10.5 \text{ g O}}{7.94 \text{ g C}} = 1.32 \text{ or } 1.32 : 1$$

$$\frac{\text{mass of carbon}}{7.88 \text{ g C}} = \frac{\text{mass of carbon}}{7.88 \text{ g C}} = 1.33 \text{ or } 1.33:1$$

The ratios of oxygen to carbon are the same in the two samples of carbon monoxide, so these results are consistent with the law of definite proportions.

$$1.2. \frac{\text{mass of hydrogen to 1 g of oxygen in water}}{\text{mass of hydrogen to 1 g of oxygen in hydrogen peroxide}} = \frac{0.125}{0.0625} = 2.00$$

The ratio of the mass of hydrogen from one compound to the mass of hydrogen in the other is equal to 2. This is a simple whole number and therefore consistent with the law of multiple proportions.

1.3. ☐

a. $Z = 6, A = 13, \text{C}^{13}_6$

b. 19 protons, 20 neutrons

1.4. ☐ 24.31 amu

1.4. ☐ For More Practice

70.92 amu

1.5. ☐ $4.65 \times 10^{-2} \text{ mol Ag}$

1.6. ☐ 0.563 mol Cu

1.6. ☐ For More Practice

22.6 g Ti

1.7. ☐ $1.3 \times 10^{22} \text{ C atoms}$

1.7. ☐ For More Practice

6.87 g W

1.8. ☐ $l = 1.72 \text{ cm}$

1.8. ☐ For More Practice

$2.90 \times 10^{24} \text{ C atoms}$

Chapter 2

2.1. ☐ $5.83 \times 10^{14} \text{ s}^{-1}$

2.2. ☐ $2.64 \times 10^{20} \text{ photons}$

2.2. ☐ For More Practice

435 nm

2.3. ☐

a. blue < green < red

b. red < green < blue

c. red < green < blue

2.4. ☐ $6.1 \times 10^6 \text{ m/s}$

2.5. ☐ For the 5d orbitals:

$n = 5$

$l = 2$

$m_l = -2, -1, 0, 1, 2$

The five integer values for m_l signify that there are five 5d orbitals.

2.6. ☐

a. l cannot equal 3 if $n = 3$. $l = 2$

b. m_l cannot equal -2 if $l = -1$. Possible values for $m_l = -1, 0$, or 1

c. l cannot be 1 if $n = 1$. $l = 0$

2.7. ☐ 397 nm

2.7. ☐ For More Practice

$n = 1$

Chapter 3

3.1.

- a. Cl $1s^2 2s^2 2p^6 3s^2 3p^5$ or [Ne] $3s^2 3p^5$
- b. Si $1s^2 2s^2 2p^6 3s^2 3p^2$ or [Ne] $3s^2 3p^2$
- c. Sr $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$ or [Kr] $5s^2$
- d. O $1s^2 2s^2 2p^4$ or [He] $2s^2 2p^4$

3.2. There are no unpaired electrons.



3.3. $1s^2 2s^2 2p^6 3s^2 3p^3$ or [Ne] $3s^2 3p^3$. The 5 electrons in the $3s^2 3p^3$ orbitals are the valence electrons, while the 10 electrons in the $1s^2 2s^2 2p^6$ orbitals belong to the core.

3.4. Bi [Xe] $6s^2 4f^{14} 5d^{10} 6p^3$

3.4. For More Practice

I [Kr] $3s^2 4d^{10} 5p^5$

3.5.

- a. N^{3-}
- b. Rb^+

3.6.

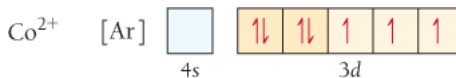
- a. Sn
- b. cannot predict
- c. W
- d. Se

3.6. For More Practice

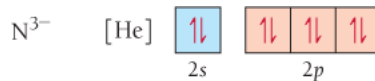
Rb > Ca > Si > S > F

3.7.

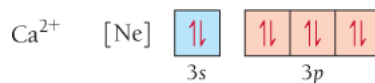
- a. [Ar] $4s^0 3d^7$. Co^{2+} is paramagnetic.



- b. [He] $2s^2 2p^6$. N^{3-} is diamagnetic.



- c. [Ne] $3s^2 3p^6$. Ca^{2+} is diamagnetic.



3.8.

- a. K
- b. F^-

c. Cl^-

3.9.

a. I

b. Ca

c. cannot predict

d. F

3.9. **For More Practice**

$\text{F} > \text{S} > \text{Si} > \text{Ca} > \text{Rb}$

3.10.

a. Sn

b. cannot predict based on simple trends (Po is larger)

c. Bi

d. B

3.10. **For More Practice**

$\text{Cl} < \text{Si} < \text{Na} < \text{Rb}$

Chapter 4

4.1.

a. C_5H_{12}

b. HgCl

c. CH_2O

4.2. Mg_3N_2

4.3. K_2S

4.4. AlN

4.5. silver nitride

4.5. **For More Practice**

Rb_2S

4.6. iron(II) sulfide

4.6. **For More Practice**

RuO_2

4.7. tin(II) chlorate

4.7. **For More Practice**

$\text{Co}_3(\text{PO}_4)_2$

4.8. dinitrogen pentoxide

4.8. **For More Practice**

PBr_3

4.9. 164.10 amu

4.10. 5.839×10^{20} $\text{C}_{13}\text{H}_{18}\text{O}_2$ molecules

4.10. **For More Practice**

1.06 g H_2O

4.11. 53.29%

4.11. **For More Practice**

74.19% Na

4.12. 83.9 g Fe_2O_3

4.12. **For More Practice**

8.6 g Na

4.13. 4.0 g O

4.13. For More Practice

3.60 g C

4.14. \square CH₂O

4.15. \square $C_{13}H_{18}O_2$

4.16. C₆H₆

4.16. For More Practice

$$\text{C}_2\text{H}_8\text{N}_2$$

4.17. \square C_2H_5

4.18. C₂H₄O

Chapter 5

5.1.

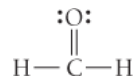
a. pure covalent

b. ionic

c. polar covalent

5.2. :C≡O:

5.3.



5.4.



5.5.



5.6.

Structure	A			B			C		
	$:\ddot{\text{N}}=\text{N}=\ddot{\text{O}}:$			$:\text{N}\equiv\text{N}-\ddot{\text{O}}:$			$:\ddot{\text{N}}-\text{N}\equiv\text{O}:$		
Number of valence e^-	5	5	6	5	5	6	5	5	6
Number of nonbonding e^-	4	0	4	2	0	6	6	0	2
$\frac{1}{2}(\text{number of bonding } e^-)$	2	4	2	3	4	1	1	4	3
Formal charge	-1	+1	0	0	+1	-1	-2	+1	+1

Structure B contributes the most to the correct overall structure of N_2O .

5.6. For More Practice

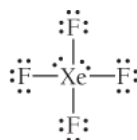
The nitrogen is +1, the singly bonded oxygen atoms are -1, and the double-bonded oxygen atom has no formal charge.

5.7.

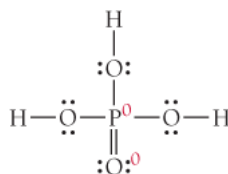




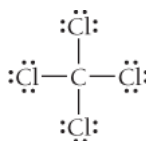
5.8.



5.8. For More Practice



5.9. tetrahedral



5.10. bent

5.11. linear

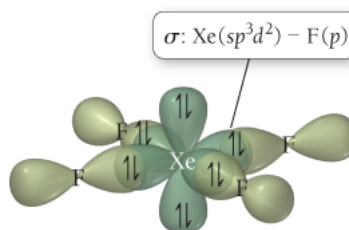
5.12.

Atom	Number of Electron Groups	Number of Lone Pairs	Molecular Geometry
Carbon (left)	4	0	Tetrahedral
Carbon (right)	3	0	Trigonal planar
Oxygen	4	2	Bent

5.13. The molecule is nonpolar.

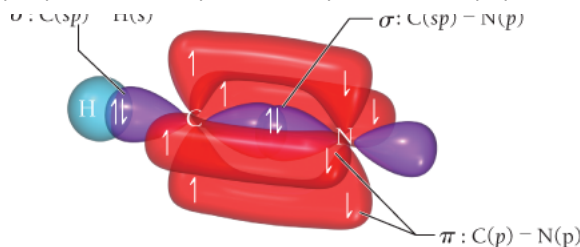
Chapter 6

6.1. The xenon atom has six electron groups and therefore has an octahedral electron geometry. An octahedral electron geometry corresponds to sp^3d^2 hybridization (refer to Table 7.1).

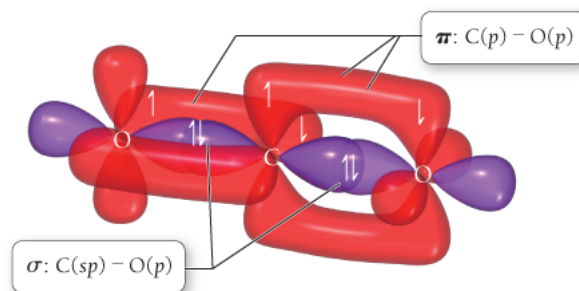


6.2. Since there are only two electron groups around the central atom (C), the electron geometry is linear. According to Table 7.1 , the corresponding hybridization on the carbon atom is sp .





6.3. Since there are only two electron groups about the central atom (C), the electron geometry is linear. The hybridization on C is sp (refer to Table 7.1).



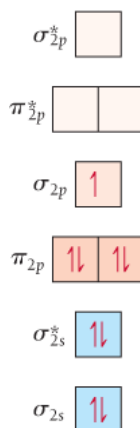
6.3. For More Practice

There are five electron groups about the central atom (I); therefore the electron geometry is trigonal bipyramidal, and the corresponding hybridization of I is sp^3d (refer to Table 7.1).

6.4. H_2^+ bond order = $+\frac{1}{2}$

Since the bond order is positive, the H_2^+ ion should be stable; however, the bond order of H_2^+ is lower than the bond order of H_2 (bond order = 1). Therefore, the bond in H_2^+ is weaker than in H_2 .

6.5. The bond order of H_2^+ is 2.5, which is lower than that of the N_2 molecule (bond order = 3); therefore the bond is weaker. The MO diagram shows that the N_2^+ ion has one unpaired electron and is therefore paramagnetic.

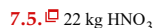
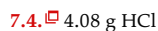
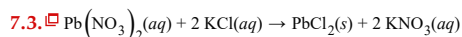
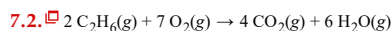
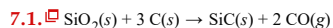


6.5. For More Practice

The bond order of Ne_2 is 0, which indicates that diatomic neon does not exist.

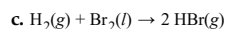
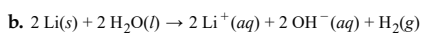
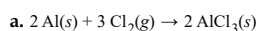
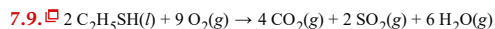
6.6. The bond order of NO is +2.5. The MO diagram shows that the ion has one unpaired electron and is therefore paramagnetic.

Chapter 7

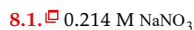


7.6. H_2 is the limiting reagent, since it produces the least amount of NH_3 . Therefore, 29.4 kg NH_3 is the theoretical yield.

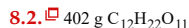
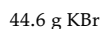
7.7. CO is the limiting reagent, since it only produces 114 g Fe. Therefore, 114 g Fe is the theoretical yield:
percentage yield = 63.4% yield.



-->Chapter 8



8.1. For More Practice



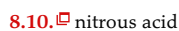
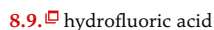
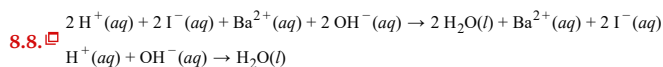
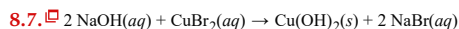
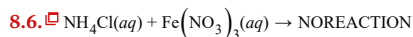
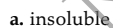
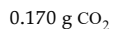
8.2. For More Practice



8.3. For More Practice



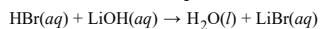
8.4. For More Practice



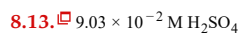
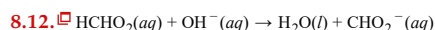
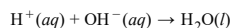
8.10. For More Practice



8.11. Molecular equation

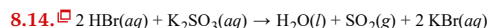


Net ionic equation

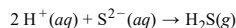


8.13. For More Practice

24.5 mL NaOH solution



8.14. For More Practice



8.15.

- a. Cr = 0.
- b. $\text{Cr}^{3+} = +3$.
- c. $\text{Cl}^- = -1$, C = +4.
- d. Br = -1, Sr = +2.
- e. O = -2, S = +6.
- f. O = -2, N = +5.

8.16. Sn is oxidized and N is reduced.

8.16. For More Practice

b. Reaction b is the only redox reaction. Al is oxidized and O is reduced.

8.17.

- a. This is a redox reaction in which Li is the reducing agent (it is oxidized) and Cl_2 is the oxidizing reagent (it is reduced).
- b. This is a redox reaction in which Al is the reducing agent and Sn^{2+} is the oxidizing agent.
- c. This is not a redox reaction because no oxidation states change.
- d. This is a redox reaction in which C is the reducing agent and O_2 is the oxidizing agent.

8.18.

- a. yes
- b. no

Chapter 9

9.1. $\Delta E = 71 \text{ J}$

9.2. $C_s = 0.38 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}$

The specific heat capacity of gold is $0.128 \text{ J/g} \cdot ^\circ\text{C}$; therefore the rock cannot be pure gold.

9.2. For More Practice

$$T_f = 42.1 ^\circ\text{C}$$

9.3. 37.8 g Cu

9.4. -122 J

9.4. For More Practice

$$\Delta E = -998 \text{ J}$$

9.5. $\Delta E_{\text{reaction}} = -3.91 \times 10^3 \text{ kJ/mol C}_6\text{H}_{14}$

9.5. For More Practice

$$C_{\text{cal}} = 4.55 \frac{\text{kJ}}{^\circ\text{C}}$$

9.6.

- a. endothermic, positive ΔH
- b. endothermic, positive ΔH
- c. exothermic, negative ΔH

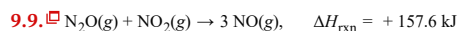
9.7. $-2.06 \times 10^3 \text{ kJ}$

9.7. For More Practice

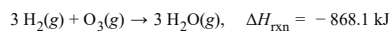
33 g C_4H_{10}

99 g CO_2

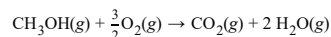
9.8. $\Delta H_{\text{rxn}} = -68 \text{ kJ}$



9.9. For More Practice



9.10.

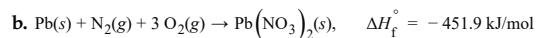
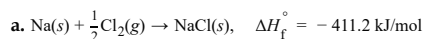


$\Delta H_{\text{rxn}} = -641 \text{ kJ}$

9.10. For More Practice

$\Delta H_{\text{rxn}} = -8.0 \times 10^1 \text{ kJ}$

9.11.



9.12. $\Delta H_{\text{rxn}}^\circ = -851.5 \text{ kJ}$

9.13. $\Delta H_{\text{rxn}}^\circ = -1648.4 \text{ kJ}$

111 kJ emitted (-111 kJ)

9.14. $\text{KI} < \text{LiBr} < \text{CaO}$

9.14. For More Practice



Chapter 10

10.1. 15.0 psi

10.1. For More Practice

80.6 kPa

10.2. 2.1 atm at a depth of approximately 11 m.

10.3. 123 mL

10.4. 11.3 L

10.5. 1.63 atm/23.9 psi

10.6. 16.1 L

10.6. For More Practice

976 mmHg

10.7. $d = 4.91 \text{ g/L}$

10.7. For More Practice

44.0 g/mol

10.8. 70.7 g/mol

10.9. 0.0610 mol H_2

10.10. 4.2 atm

10.11. 12.0 mg H_2

10.12. $u_{\text{rms}} = 238 \text{ m/s}$

10.13. $\frac{\text{rate}_{\text{H}_2}}{\text{rate}_{\text{Kr}}} = 6.44$

10.14. 82.3 g Ag_2O

10.14. For More Practice

7.10 g Ag₂O

10.15. ☐ 6.53 L O₂

Chapter 11

11.1. ☐ b, c

11.2. ☐ HF has a higher boiling point than HCl because, unlike HCl, HF is able to form hydrogen bonds. The hydrogen bond is the strongest of the intermolecular forces and requires more energy to break.

11.3. ☐ 5.83×10^3 kJ

11.3. ☐ For More Practice

49 °C

11.4. ☐ 33.8 kJ/mol

11.5. ☐ 7.04×10^3 torr

11.6. ☐ No phase transition occurs.

Chapter 12

12.1. ☐ 29.4°

12.2. ☐ 78.5%

12.3. ☐ 3.24×10^{-23} cm³

12.4. ☐ $7.18 \frac{\text{g}}{\text{cm}^3}$

12.5. ☐ metallic

Chapter 13

13.1. ☐

a. not soluble

b. soluble

c. not soluble

d. not soluble

13.2. ☐ 2.7×10^{-4} M

13.3. ☐ 42.5 g C₁₂H₂₂O₁₁

13.3. ☐ For More Practice

3.3×10^4 L

13.4. ☐

a. $M = 0.415$ M

b. $m = 0.443$ m

c. % by mass = 13.2 %

d. $\chi_{\text{C}_{12}\text{H}_{22}\text{O}_{11}} = 0.00793$

e. mole percent = 0.793 %

13.5. ☐ 0.600 M

13.5. ☐ For More Practice

0.651 *m*

13.6. ☐ 22.5 torr

13.6. ☐ For More Practice

0.144

13.7.

$$P_{\text{benzene}} = 26.6 \text{ torr}$$

a. $P_{\text{toluene}} = 20.4 \text{ torr}$

b. 47.0 torr

c. 52.5% benzene; 47.5% toluene

The vapor will be richer in the more volatile component, which in this case is benzene.

13.8. $T_f = -4.8^\circ\text{C}$

13.9. 101.84°C

13.10. 11.8 atm

13.11. -0.60°C

13.12. 0.014 mol NaCl

Chapter 14

14.1.

$$\frac{\Delta [\text{H}_2\text{O}_2]}{\Delta t} = -4.40 \times 10^{-3} \text{ M/s}$$

$$\frac{\Delta [\text{I}_3^-]}{\Delta t} = 4.40 \times 10^{-3} \text{ M/s}$$

14.2.

a. $\text{Rate} = k [\text{CHCl}_3][\text{Cl}_2]^{1/2}$. (Fractional-order reactions are not common but are occasionally observed.)

b. $3.5 \text{ M}^{-1/2} \cdot \text{s}^{-1}$

14.3. $5.78 \times 10^{-2} \text{ M}$

14.4. 0.0277 M

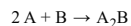
14.5. $1.64 \times 10^{-3} \text{ M}$

14.6. 79.2 s

14.7. $2.07 \times 10^{-5} \frac{\text{L}}{\text{mol} \cdot \text{s}}$

14.8. $6.13 \times 10^{-4} \frac{\text{L}}{\text{mol} \cdot \text{s}}$

14.9.



$$\text{Rate} = k[\text{A}]^2$$

Chapter 15

15.1. $K = \frac{[\text{CO}_2]^2 [\text{H}_2\text{O}]^4}{[\text{C}_3\text{H}_8] [\text{O}_2]^5}$

15.2. 2.1×10^{-13}

15.2. For More Practice

$$1.4 \times 10^2$$

15.3. 6.2×10^2

15.4. $K_c = \frac{[\text{Cl}_2]^2}{[\text{HCl}]^4 [\text{O}_2]}$

15.5. 9.4

15.6. 1.1×10^{-6}

15.7. $Q_c = 0.0196$

Reaction proceeds to the left.

15.8. 0.033 M

15.9.

$$[\text{N}_2] = 4.45 \times 10^{-3} \text{ M}$$

$$[\text{O}_2] = 4.45 \times 10^{-3} \text{ M}$$

$$[\text{NO}] = 1.1 \times 10^{-3} \text{ M}$$

15.10.

$$[\text{N}_2\text{O}_4] = 0.005 \text{ M}$$

$$[\text{NO}_2] = 0.041 \text{ M}$$

15.11.

$$P_{\text{I}_2} = 0.0027 \text{ atm}$$

$$P_{\text{Cl}_2} = 0.0027 \text{ atm}$$

$$P_{\text{ICl}_2} = 0.246 \text{ atm}$$

15.12. $1.67 \times 10^{-7} \text{ M}$

15.13. $6.78 \times 10^{-6} \text{ M}$

15.14. Adding Br_2 increases the concentration of Br_2 , causing a shift to the left (away from the Br_2). Adding

BrNO increases the concentration of BrNO , causing a shift to the right.

15.15. Decreasing the volume causes the reaction to shift right. Increasing the volume causes the reaction to shift left.

15.16. If we increase the temperature, the reaction shifts to the left. If we decrease the temperature, the reaction shifts to the right.

Chapter 16

16.1.

- a. H_2O donates a proton to $\text{C}_5\text{H}_5\text{N}$, making it the acid. The conjugate base is therefore OH^- . Since $\text{C}_5\text{H}_5\text{N}$ accepts the proton, it is the base and becomes the conjugate acid $\text{C}_5\text{H}_5\text{NH}^+$.
- b. Since HNO_3 donates a proton to H_2O it is the acid, making NO_3^- the conjugate base. Since H_2O is the proton acceptor, it is the base and becomes the conjugate acid, H_3O^+ .

16.2.

a. $[\text{H}_3\text{O}^+] = 6.7 \times 10^{-13} \text{ M}$

Since $[\text{H}_3\text{O}^+] < [\text{OH}^-]$ the solution is basic.

b. $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-7} \text{ M}$

Neutral solution.

c. $[\text{H}_3\text{O}^+] = 1.2 \times 10^{-3} \text{ M}$

Since $[\text{H}_3\text{O}^+] > [\text{OH}^-]$ the solution is acidic.

16.3.

a. 8.02 (basic)

b. 11.85 (basic)

16.4. $4.3 \times 10^{-9} \text{ M}$

16.5. $9.4 \times 10^{-3} \text{ M}$

16.6. 3.28

16.7. 2.72

16.8. 1.8×10^{-6}

16.9. 0.85%

16.10. $2.1 \times 10^{-7} \text{ M}$

16.11.

$$[\text{OH}^-] = 0.020 \text{ M}$$

$$\text{pH} = 12.30$$

16.12. \square $[\text{OH}^-] = 1.2 \times 10^{-4} \text{ M}$
 $\text{pH} = 12.08$

16.13. \square

- a. weak base
- b. pH-neutral

16.14. \square 9.07

16.15. \square

- a. pH-neutral
- b. weak acid
- c. weak acid

16.16. \square

- a. basic
- b. acidic
- c. pH-neutral
- d. acidic

16.17. \square 3.83

16.18. \square $[\text{SO}_4^{2-}] = 0.00386 \text{ M}$
 $\text{pH} = 1.945$

16.19. \square $5.6 \times 10^{-11} \text{ M}$

Chapter 17

17.1. \square 4.44

17.1. \square For More Practice

3.44

17.2. \square 9.14

17.3. \square 4.87

17.3. \square For More Practice

4.65

17.4. \square 9.68

17.4. \square For More Practice

9.56

17.5. \square hypochlorous acid (HClO), 2.4 g NaClO

17.6. \square 1.74

17.7. \square 8.08

17.8. \square $2.30 \times 10^{-6} \text{ M}$

17.9. \square 5.3×10^{-13}

17.10. \square $1.21 \times 10^{-5} \text{ M}$

17.11. \square FeCO_3 will be more soluble in an acidic solution than PbBr_2 because the CO_3^{2-} ion is a basic anion,

whereas Br^- is the conjugate base of a strong acid (HBr) and is therefore pH-neutral.

17.12. \square $Q > K_{\text{sp}}$; therefore, a precipitate forms.

17.13. \square $2.9 \times 10^{-6} \text{ M}$

17.14. \square

a. AgCl precipitates first; $[\text{NaCl}] = 7.1 \times 10^{-9} \text{ M}$

b. $[\text{Ag}^+]$ is $1.5 \times 10^{-8} \text{ M}$ when PbCl_2 begins to precipitate, and $[\text{Pb}^{2+}]$ is 0.085 M.

17.15. \square $9.6 \times 10^{-6} \text{ M}$

Chapter 18

18.1. 


- a. positive
- b. negative
- c. positive

18.2.  15.2 J/K18.3. 



- a. -548 J/K
- b. ΔS_{sys} is negative.
- c. ΔS_{univ} is negative, and the reaction is not spontaneous.

18.3.  For More Practice


375 K

18.4.  $\Delta G = -101.6 \times 10^3 \text{ J}$


Therefore, the reaction is spontaneous. Since both ΔH and ΔS are negative, as the temperature increases ΔG will become more positive.

18.5.  -153.2 J/K 18.6.  $\Delta G_{\text{rxn}}^{\circ} = -36.3 \text{ kJ}$

Since $\Delta G_{\text{rxn}}^{\circ}$ is negative, the reaction is spontaneous at this temperature.

18.7.  $\Delta G_{\text{rxn}}^{\circ} = -42.1 \text{ kJ}$

Since the value of $\Delta G_{\text{rxn}}^{\circ}$ at the lowered temperature is more negative (or less positive) (which is -36.3 kJ), the reaction is more spontaneous.


18.8.  $\Delta G_{\text{rxn}}^{\circ} = -689.6 \text{ kJ}$

Since $\Delta G_{\text{rxn}}^{\circ}$ is negative, the reaction is spontaneous at this temperature.

18.8.  For More Practice $\Delta G_{\text{rxn}}^{\circ} = -689.7 \text{ kJ}$ (at 25°)

The value calculated for $\Delta G_{\text{rxn}}^{\circ}$ from the tabulated values (-689.6 kJ) is the same, to within 1 in the least significant digit, as the value calculated using the equation for $\Delta G_{\text{rxn}}^{\circ}$. $\Delta G_{\text{rxn}}^{\circ} = -649.7 \text{ kJ}$ (at 500.0 K)



You could not calculate $\Delta G_{\text{rxn}}^{\circ}$ at 500.0 K using tabulated ΔG_f° values because the tabulated values of free energy are calculated at a standard temperature of 298 K , much lower than 500 K .

18.9.  $+107.1 \text{ kJ}$ 18.10.  $\Delta G_{\text{rxn}} = -129 \text{ kJ}$


The reaction is more spontaneous under these conditions than under standard conditions because ΔG_{rxn} is more negative than $\Delta G_{\text{rxn}}^{\circ}$.

18.11.  -10.9 kJ

Chapter 19

19.1.  $2 \text{ Cr(s)} + 4 \text{ H}^{+}(\text{aq}) \rightarrow 2 \text{ Cr}^{2+}(\text{aq}) + 2 \text{ H}_2(\text{g})$ 19.2.  $\text{Cu(s)} + 4 \text{ H}^{+}(\text{aq}) + 2 \text{ NO}_3^{-}(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2 \text{ NO}_2(\text{g}) + 2 \text{ H}_2\text{O}(\text{l})$ 19.3.  $3 \text{ ClO}^{-}(\text{aq}) + 2 \text{ Cr(OH)}_4^{-}(\text{aq}) + 2 \text{ OH}^{-}(\text{aq}) \rightarrow 3 \text{ Cl}^{-}(\text{aq}) + 2 \text{ CrO}_4^{2-}(\text{aq}) + 5 \text{ H}_2\text{O}(\text{l})$ 19.4.  $+0.60 \text{ V}$ 19.5. 

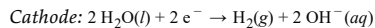
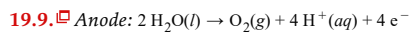
- a. The reaction *will* be spontaneous as written.
- b. The reaction *will not* be spontaneous as written.

19.6.  $\Delta G^{\circ} = -3.63 \times 10^5 \text{ J}$

Since ΔG° is negative, the reaction is spontaneous.

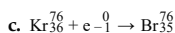
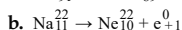
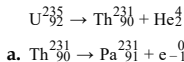
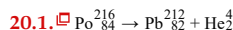
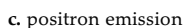
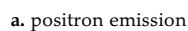
19.7. 4.5×10^3

19.8. 1.08 V



19.10. $6.0 \times 10^1 \text{ min}$

Chapter 20

20.2. **For More Practice**Positron emission ($\text{K}_{19}^{40} \rightarrow \text{Ar}_{18}^{40} + \text{e}_{+1}^0$) or electron capture ($\text{K}_{19}^{40} + \text{e}_{-1}^0 \rightarrow \text{Ar}_{18}^{40}$)

20.4. 10.7 yr

20.5. $t = 964 \text{ yr}$

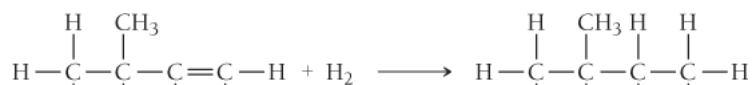
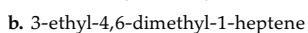
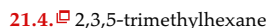
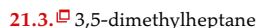
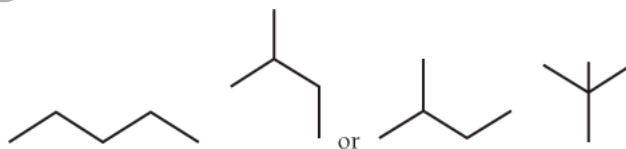
No, the C-14 content suggests that the scroll is from about A.D. 1000, not 500 B.C.

20.6. $1.0 \times 10^9 \text{ yr}$

20.7. $\text{Mass defect} = 1.934 \text{ amu}$

$\text{Nuclear binding energy} = 7.569 \text{ MeV/nucleon}$

Chapter 21



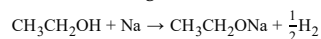


b. 2-chloro-3-methylbutane

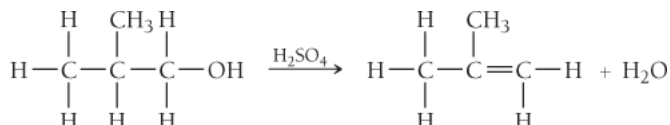


21.7. 


a. Alcohol reacting with an active metal.





b. dehydration reaction



Chapter 22

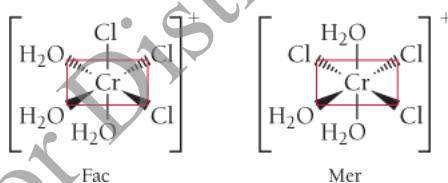
22.1.  [Xe] $6s^2 4f^{14} 5d^6$


22.2.  [Kr] $5s^0 4d^3$ or [Kr] $4d^3$

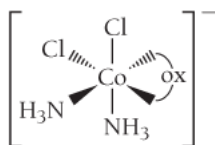
22.3.  pentaamminecarbonylmanganese(II) sulfate

22.4.  sodium tetrachloroplatinate(II)

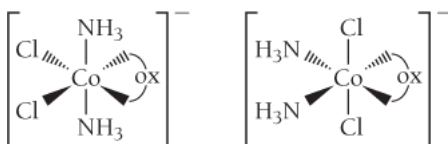
22.5.  The complex ion $[\text{Cr}(\text{H}_2\text{O})_3\text{Cl}_3]^+$ fits the general formula MA_3B_3 , which results in fac and mer isomers.



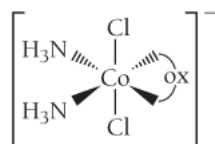
22.6.  The oxalate ligand is a small bidentate ligand, so it will have to occupy two adjacent (cis) positions of the octahedron. There are three ways to arrange the two NH_3 and two Cl^- ligands in the four remaining positions. One has both NH_3 and both Cl^- in cis positions (cis isomer). Another has the NH_3 ligands in a trans arrangement with both Cl^- in cis positions (*trans*-ammine isomer). The third has both NH_3 ligands cis and the Cl^- ligands trans (*trans*-chloro isomer).



Cis isomer



Trans (in NH_3)



Trans (in Cl^-)

22.7. ☐ Both the fac and mer isomers are superimposable (by rotating 180°) on their mirror images, so neither one is optically active.

22.8. ☐ 288 kJ/mol

22.9. ☐ 5 unpaired electrons

22.10. ☐ 1 unpaired electron

Not for Distribution

Not for Distribution

Not for Distribution