

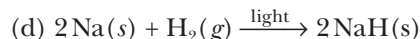
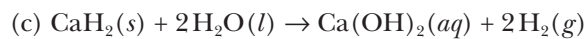
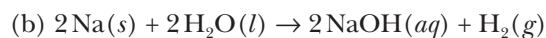
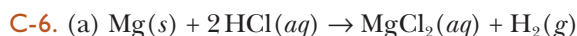
# Solutions to the Even-Numbered Questions

## Interchapter C

### Hydrogen and Oxygen

C-2. The naturally occurring isotopes of hydrogen are hydrogen, deuterium, and tritium.

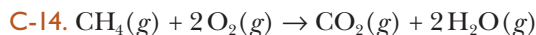
C-4. The Haber process is the industrial production of ammonia directly from hydrogen and nitrogen.



C-8. Sand is predominantly silicon dioxide,  $\text{SiO}_2(s)$ .

C-10. Photosynthesis is the source of most of the oxygen in the atmosphere.

C-12. A catalyst is a substance that increases the rate of a chemical reaction without itself being consumed.



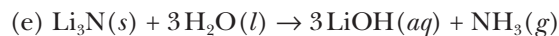
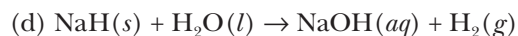
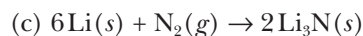
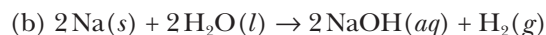
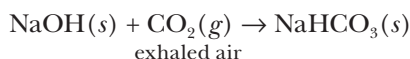
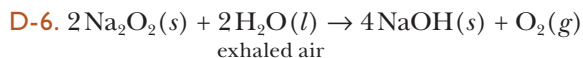
C-16. Allotropes are two or more different forms of an element that have a different number or arrangement of the atoms in the constituent molecules.

## Interchapter D

### The Alkali Metals

D-2. The alkali metals are produced commercially by electrolysis of their molten salts.

D-4. Lithium is the only element that reacts with nitrogen at room temperature.



## Interchapter E

## Nitrogen

**E-2.** The volume percentage of  $\text{N}_2(g)$  in the lower atmosphere is about 78%.

**E-4.** Lithium is the only element that reacts with  $\text{N}_2(g)$  at room temperature.

**E-6.** The Haber process is the synthesis of ammonia directly from hydrogen and nitrogen under controlled conditions of high temperature and high pressure with a catalyst.

**E-8.** Azides are salts of hydrazoic acid,  $\text{HN}_3(aq)$ . They are made by reacting the metal hydroxide with  $\text{HN}_3(aq)$ .

**E-10.** Laughing gas is  $\text{N}_2\text{O}(g)$ , dinitrogen oxide or nitrous oxide.

## Interchapter F

## Saturated Hydrocarbons

**F-2.** A substitution reaction is the substitution of one atom for another in a molecule.

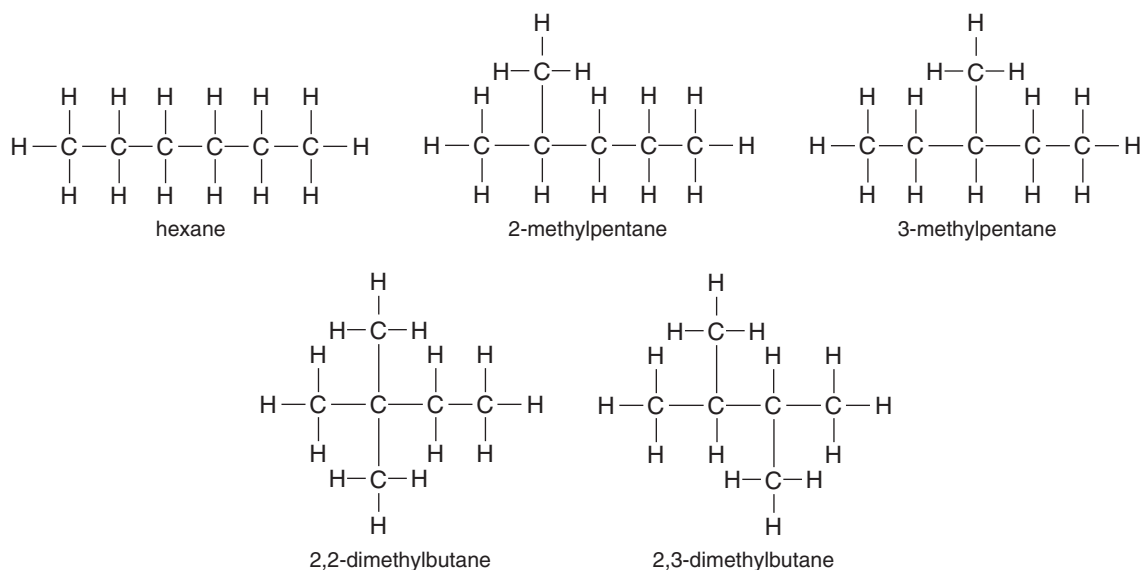
**F-4.** (a) The molecules are identical. One can be flipped over and superimposed upon the other.

(b) The molecules are identical. The chlorine atom is attached to the second carbon atom in each molecule.

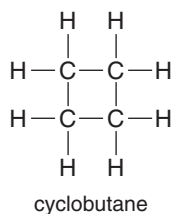
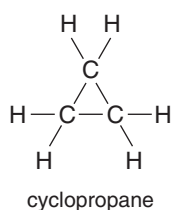
(c) The molecules are identical. One can be rotated  $180^\circ$  and superimposed upon the other.

(d) The molecules are identical. The chlorine atom is attached to the first carbon atom in each molecule.

**F-6.** The Lewis formulas are

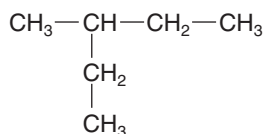


F-8. The Lewis formulas are



F-10. (a) The name violates rule 3. The chain was not numbered to give the lowest number to the carbon atom that has an attached group. The correct IUPAC name is 2-methylpentane.

(b) The Lewis formula of the compound is

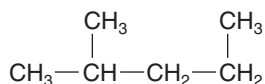


The name violates rule 2. The correct IUPAC name is 3-methylpentane.

(c) One of the methyl groups has not been numbered (rule 6). The correct IUPAC name is 2,2-dimethylpropane.

(d) The name violates rule 3. The chloro groups have not been assigned the lowest numbers. The correct IUPAC name is 1,2-dichloropropane.

(e) The Lewis formula of the compound is



The longest chain has not been used (rule 2). The correct IUPAC name is 2-methylpentane.

F-12. 1-chloropropane and “3-chloropropane” are the same molecule. One formula can be obtained from the other by just rotating it 180°.

F-14. The IUPAC names of the alkanes are 1: 2,3-dimethylpentane, 2: 2,3,3-trimethylpentane, 3: 3,4-dimethylhexane, and 4: 2,3-dimethylpentane.

(a) 1 and 4 are the same compound.

(b) 2 and 3 are isomers of octane.

(c) 3 is a derivative of hexane.

(d) 2 has the most methyl groups.

## Interchapter G

### Unsaturated Hydrocarbons

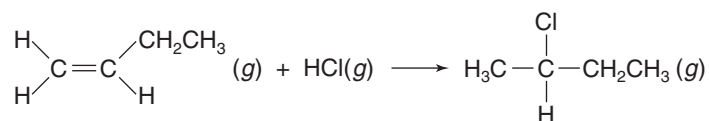
**G-2.** An addition reaction results when atoms are added to a molecule, such as an unsaturated hydrocarbon. A substitution reaction results when one atom is substituted for another in a molecule.

**G-4.** Markovnikov's rule says that when HX adds to an alkene in an addition reaction, the hydrogen atom attaches to the carbon atom in a double or triple bond bearing a larger number of hydrogen atoms.

**G-6.** Yes. For example, the addition of  $\text{Cl}_2(g)$  to acetylene,  $\text{H}-\text{C}\equiv\text{C}-\text{H}$ , can result in *cis* and *trans* isomers of 1,2-dichlorethene.

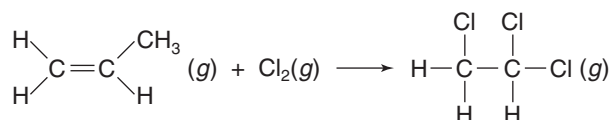
**G-8.** (a) 3-fluoro-1-butene (b) 2-chloro-3-methyl-*cis*-2-pentene (c) 2-pentene

**G-10.** (a) The reaction is



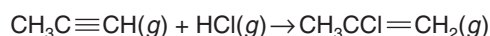
The product is 2-chlorobutane.

(b) The reaction is



The product is 1,2-dichloropropane.

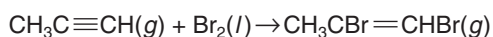
**G-12.** (a) This reaction can be broken down into two steps. We shall use Markovnikov's rule to predict the product in each step. The first step is



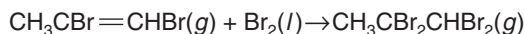
The second step is



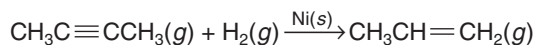
(b) The first step is



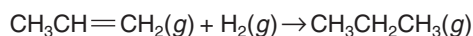
The second step is



(c) The first step is



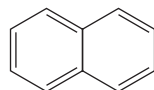
The second step is



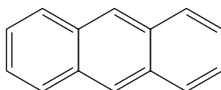
## Interchapter H

### Aromatic Hydrocarbons

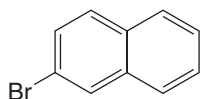
H-2. The Lewis formulas of naphthalene and anthracene are



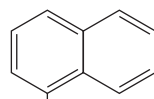
naphthalene



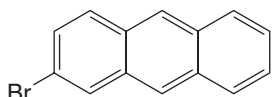
anthracene



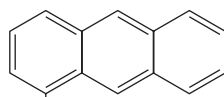
Br



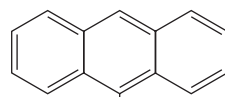
Br



Br



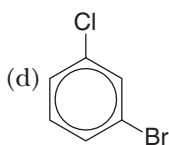
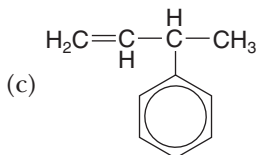
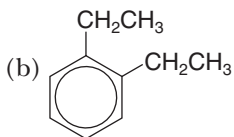
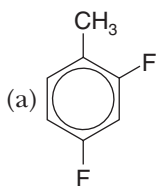
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There are two isomers of bromonaphthalene and three isomers of bromoanthracene.

H-4. The Lewis formulas are



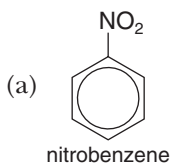
H-6. (a) 3-chlorotoluene

(b) 1,2-dichlorobenzene

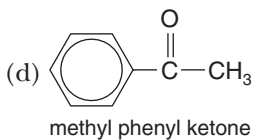
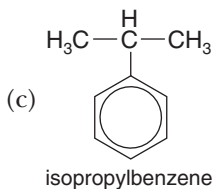
(c) 1-chloro-4-ethylbenzene

(d) toluene

H-8. The products are

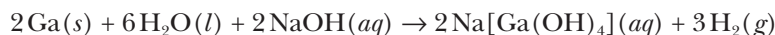
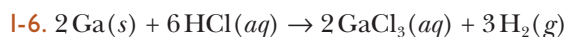
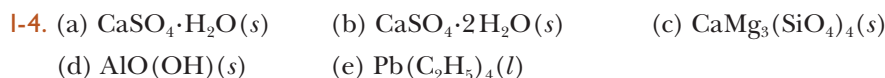


(b) no reaction



### Interchapter I Main Group Metals

I-2. You should not throw water on a magnesium fire because hot magnesium reacts vigorously with water.



I-8. The conversion of a white allotrope of tin to a brittle gray allotrope below  $13^\circ\text{C}$ .

I-10. (a)  $(1.00 \text{ kg}) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol PbS}}{239.3 \text{ g PbS}} \right) \left( \frac{1 \text{ mol Pb}}{1 \text{ mol PbS}} \right) \left( \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} \right) = 866 \text{ g}$

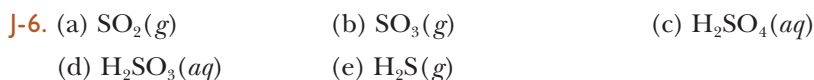
(b)  $(1.00 \text{ kg}) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol PbSO}_4}{303.3 \text{ g PbSO}_4} \right) \left( \frac{1 \text{ mol Pb}}{1 \text{ mol PbSO}_4} \right) \left( \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} \right) = 683 \text{ g}$

(c)  $(1.00 \text{ kg}) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol PbCO}_3}{267.2 \text{ g PbCO}_3} \right) \left( \frac{1 \text{ mol Pb}}{1 \text{ mol PbCO}_3} \right) \left( \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} \right) = 775 \text{ g}$

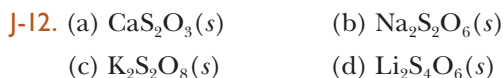
### Interchapter J Sulfur

J-2. Salts of sulfuric acid are called sulfates and salts of sulfurous acid are called sulfites.

J-4. The formula for Epsom salt is  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}(s)$ .



J-8. Monoclinic sulfur melts at  $119^\circ\text{C}$  to a thin yellow liquid consisting of  $\text{S}_8$  rings. Upon heating to about  $150^\circ\text{C}$ , there is little change, but beyond  $150^\circ\text{C}$ , the liquid sulfur turns reddish brown and begins to thicken due to polymerization of broken  $\text{S}_8$  rings. By  $200^\circ\text{C}$ , the liquid is so thick that it hardly pours.



### Interchapter K Noble Gases

K-2. Rayleigh was led to the discovery of argon by a discrepancy in the density of nitrogen obtained from the removal of oxygen, water vapor, and carbon dioxide from air and the density of nitrogen prepared from the thermal decomposition of  $\text{NH}_4\text{NO}_2(aq)$ .

**K-4.** The noble gases were placed in a new group in the periodic table because they behaved chemically as an entire new family of elements.

**K-6.** See Figure K.1.

**K-8.** Nitrogen reacts with lithium at room temperature, whereas argon does not.

**K-10.** The shapes of the given compounds are

$\text{RnF}_2$   $\text{AX}_2\text{E}_3$  linear                       $\text{RnF}_4$   $\text{AX}_4\text{E}_2$  square planar

$\text{RnO}_3$   $\text{AX}_3\text{E}$  trigonal pyramidal       $\text{RnO}_4$   $\text{AX}_4$  tetrahedral

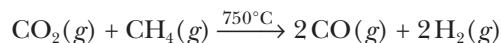
## Interchapter L

### Sources of Energy

**L-2.** Solar energy can be stored by (1) the dissolution of Glauber's salt,  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}(s)$ , in its own waters of hydration reaction described by



or by (2) the production of  $\text{H}_2(g)$  such as

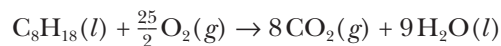


**L-4.** We have that

$$\begin{aligned} \left( \frac{\text{average power}}{\text{consumed per person}} \right) &= (3.5 \times 10^8 \text{ kJ} \cdot \text{person}^{-1} \cdot \text{yr}^{-1}) \left( \frac{1000 \text{ J}}{1 \text{ kJ}} \right) \left( \frac{1 \text{ yr}}{365 \text{ d}} \right) \\ &\quad \times \left( \frac{1 \text{ d}}{24 \text{ hr}} \right) \left( \frac{1 \text{ hr}}{3600 \text{ s}} \right) \\ &= 1.1 \times 10^4 \text{ J} \cdot \text{s}^{-1} = 1.1 \times 10^4 \text{ W} \end{aligned}$$

$$\text{number of 100-watt light bulbs} = \frac{1.1 \times 10^4 \text{ W}}{100 \text{ W}} = 110 \text{ light bulbs}$$

**L-6.** The equation for the combustion of octane is



A 12-gallon tank of octane corresponds to

$$\begin{aligned} \text{moles C}_8\text{H}_{18}(l) &= (12 \text{ gal}) \left( \frac{3.7854 \text{ L}}{1 \text{ gal}} \right) \left( \frac{1000 \text{ ml}}{1 \text{ L}} \right) \left( \frac{0.80 \text{ g}}{1 \text{ mL}} \right) \left( \frac{1 \text{ mol}}{114.2 \text{ g}} \right) \\ &= 318 \text{ mol C}_8\text{H}_{18}(l) \end{aligned}$$

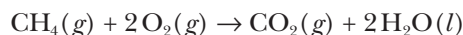
From the stoichiometry of the chemical equation, we find that

$$\text{moles CO}_2 = (318 \text{ mol C}_8\text{H}_{18}) \left( \frac{8 \text{ mol CO}_2}{1 \text{ mol C}_8\text{H}_{18}} \right) = 2500 \text{ mol}$$

The mass of  $\text{CO}_2(g)$  is

$$\text{mass of CO}_2 = (2500 \text{ mol CO}_2)(44.0 \text{ g} \cdot \text{mol}^{-1} \text{ CO}_2) = 1.1 \times 10^5 \text{ g} = 110 \text{ kg}$$

L-8. The equation for the combustion of methane is



$$\begin{aligned}\Delta H_{\text{rxn}}^{\circ} &= \Delta H_{\text{f}}^{\circ}[\text{CO}_2(g)] + 2\Delta H_{\text{f}}^{\circ}[\text{H}_2\text{O}(l)] - \Delta H_{\text{f}}^{\circ}[\text{CH}_4(g)] \\ &= (1)(-393.5 \text{ kJ}\cdot\text{mol}^{-1}) + (2)(-285.8 \text{ kJ}\cdot\text{mol}^{-1}) - (1)(-74.6 \text{ kJ}\cdot\text{mol}^{-1}) \\ &= -890.5 \text{ kJ}\cdot\text{mol}^{-1}\end{aligned}$$

The cost per mole of methane is

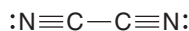
$$\text{cost per mol CH}_4 = (890.5 \text{ kJ}\cdot\text{mol}^{-1}) \left( \frac{1 \text{ BTU}}{1.05 \text{ kJ}} \right) \left( \frac{1 \text{ therm}}{100\,000 \text{ BTU}} \right) \left( \frac{\$1.20}{1 \text{ therm}} \right) = \$0.010$$

L-10. We have that

$$(0.5 \text{ kW}\cdot\text{m}^{-2})(30 \text{ m}^2)(0.25)(8 \text{ h}) = 30 \text{ kW}\cdot\text{h}$$

### Interchapter M Carbon and Silicon

M-2. The Lewis formula is



M-4. The allotropes of carbon are carbon, graphite, diamond, and the various fullerene molecules such as buckminsterfullerene.

M-6. Diamond is a covalently bonded crystal consisting of tetrahedrally arranged carbon atoms, and so has very strong bonding within the crystal. Graphite, on the other hand, consists of covalently bonded layers, with relatively weak interlayer bonding. The hardness of diamond makes it ideal for coating tool bits. The slipperiness of graphite makes it an ideal dry lubricant.

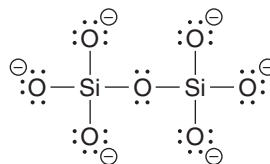
M-8. See the Interchapter.

M-10. Photochromic glasses contain a small amount of silver chloride dispersed throughout the glass. When sunlight strikes the glass, the tiny dispersed crystals of  $\text{AgCl}(s)$  decompose according to



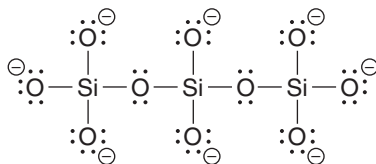
M-12. The principal component of glass is pure sand,  $\text{SiO}_2(s)$ . Other important components are soda ash,  $\text{Na}_2\text{CO}_3(s)$ , lime,  $\text{CaCO}_3(s)$ , and aluminum oxide,  $\text{Al}_2\text{O}_3(s)$ .

M-14. (a) The structure is





(b) The structure is



(c) See Figure M.11a.

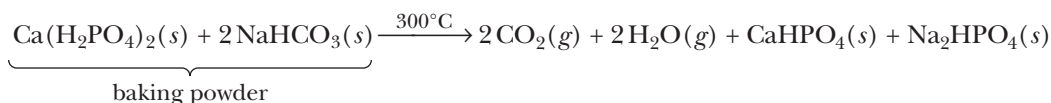
## Interchapter N Phosphorus

**N-2.** The molecular structure of  $P_4$  is tetrahedral with each phosphorus atom occupying a vertex of the tetrahedron. (See Figure N.1.)

**N-4.** Phosphate rock is a mineral of phosphate consisting of various calcium phosphate salts. Its principal use is in the production of fertilizers.

**N-6.** See Figure N.3.

**N-8.** The evolution of  $CO_2(g)$  that takes place when baking powder is heated is described by

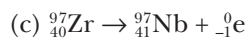
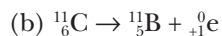
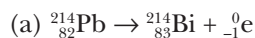


**N-10.** Phosphine is a much weaker base than ammonia because a phosphorus atom is much less electronegative than a nitrogen atom.

**N-12.** Strike-anywhere matches contain a tip composed of  $P_4S_3(s)$ ,  $PbO_2(s)$ , and  $Sb_2S_3(s)$ . Friction causes the  $P_4S_3(s)$  to ignite in air, and the heat produced then initiates a reaction between antimony sulfide and lead dioxide, which produces a flame. Safety matches consist of a mixture of potassium chlorate and antimony sulfide. The match is ignited by striking it on a special rough surface composed of a mixture of red phosphorus, glue, and abrasive. The red phosphorus is ignited by friction and in turn ignites the reaction mixture in the match head.

## Interchapter O Radiochemistry

**O-2.** The nuclear equations are as follows:



**O-4.** The value of the mass lost per second is given by

$$\Delta m = \frac{\Delta E}{c^2} = \frac{-1 \times 10^{26} \text{ J} \cdot \text{s}^{-1}}{8.99 \times 10^{16} \text{ m}^2 \cdot \text{s}^{-2}} = -1 \times 10^9 \text{ kg} \cdot \text{s}^{-1}$$

or 1 billion kilograms per second.

**O-6.** The mass of an electron or a positron is  $9.109 \times 10^{-31} \text{ kg}$ . The loss of mass is

$$\Delta m = (2)(-9.109 \times 10^{-31} \text{ kg}) = -1.822 \times 10^{-30} \text{ kg}$$

The energy produced by the reaction is

$$\begin{aligned}\Delta E &= c^2\Delta m = (8.98755 \times 10^{16} \text{ m}^2\cdot\text{s}^{-2})(-1.822 \times 10^{-30} \text{ kg}) \\ &= -1.637 \times 10^{-13} \text{ J}\end{aligned}$$

The energy of each  $\gamma$ -ray is

$$E = \frac{1}{2}(-1.637 \times 10^{-13} \text{ J}) = -8.187 \times 10^{-14} \text{ J}$$

Recall that the energy and frequency of electromagnetic radiation are related by Equation 4.3,  $E = h\nu$ , and so the frequency of each  $\gamma$ -ray is

$$\nu = \frac{E}{h} = \frac{8.187 \times 10^{-14} \text{ J}}{6.6261 \times 10^{-34} \text{ J}\cdot\text{s}^{-1}} = 1.236 \times 10^{20} \text{ Hz}$$

**O-8.** The specific activity is given by

$$\begin{aligned}\text{specific activity} &= \frac{4.17 \times 10^{23} \text{ disintegrations}}{Mt_{1/2}} \\ &= \frac{4.17 \times 10^{23} \text{ disintegrations}}{(18.00 \text{ g})(110 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right)} \\ &= 3.51 \times 10^{18} \text{ disintegrations}\cdot\text{s}^{-1}\cdot\text{g}^{-1}\end{aligned}$$

In units of curies, we have

$$\text{specific activity} = \frac{3.51 \times 10^{18} \text{ disintegrations}\cdot\text{s}^{-1}\cdot\text{g}^{-1}}{3.7 \times 10^{10} \text{ disintegrations}\cdot\text{s}^{-1}\cdot\text{Ci}^{-1}} = 9.5 \times 10^7 \text{ Ci}\cdot\text{g}^{-1}$$

**O-10.** We first convert the half life to seconds

$$t_{1/2} = (25 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 1500 \text{ s}$$

The specific activity of iodine-128 is

$$\text{specific activity} = \frac{4.17 \times 10^{23} \text{ disintegrations}}{(128 \text{ g})(1500 \text{ s})} = 2.17 \times 10^{18} \text{ disintegrations}\cdot\text{s}^{-1}\cdot\text{g}^{-1}$$

The rate of decay of a 100  $\mu\text{Ci}$  dose is

$$\begin{aligned}\text{rate of decay} &= (100 \mu\text{Ci})\left(\frac{10^{-6} \text{ Ci}}{1 \mu\text{Ci}}\right)(3.7 \times 10^{10} \text{ disintegrations}\cdot\text{Ci}^{-1}) \\ &= 3.7 \times 10^6 \text{ disintegrations}\cdot\text{s}^{-1}\end{aligned}$$

The number of grams of iodine-128 that is equivalent to this dose is

$$\text{mass} = \frac{3.7 \times 10^6 \text{ disintegrations}\cdot\text{s}^{-1}}{2.17 \times 10^{18} \text{ disintegrations}\cdot\text{s}^{-1}\cdot\text{g}^{-1}} = 1.7 \times 10^{-12} \text{ g}$$

O-12. The number of grams of barium in the precipitate is

$$\text{mass of Ba}^{2+} = \frac{3270 \text{ disintegrations} \cdot \text{min}^{-1}}{7.6 \times 10^7 \text{ disintegrations} \cdot \text{min}^{-1} \cdot \text{g}^{-1}} = 4.3 \times 10^{-5} \text{ g}$$

The number of moles of barium-131 is

$$\text{moles of Ba-131} = (4.3 \times 10^{-5} \text{ g Ba-131}) \left( \frac{1 \text{ mol Ba-131}}{131 \text{ g Ba-131}} \right) = 3.3 \times 10^{-7} \text{ mol}$$

The number of moles of  $\text{SO}_4^{2-}(aq)$  is

$$\text{moles of SO}_4^{2-} = \text{moles of BaSO}_4 = \text{moles Ba-131} = 3.3 \times 10^{-7} \text{ mol}$$

Assuming that essentially all the sulfate is precipitated (barium is in excess), we calculate the concentration of sulfate ion as

$$[\text{SO}_4^{2-}] = \frac{3.3 \times 10^{-7} \text{ mol}}{0.010 \text{ L}} = 3.3 \times 10^{-5} \text{ M}$$

O-14. This problem involves isotopic dilution and so we apply the equation,

$$m_u = m_2 \frac{A_1}{A_2} - m_1$$

where  $m_u$  is the mass of threonine present in the original sample;  $m_1$  and  $A_1$  the respective mass and activity of the carbon-14 labeled threonine added; and  $m_2$  and  $A_2$  the respective mass and activity of the radio-labeled threonine isolated from the mixture. Substituting these values into the equation gives

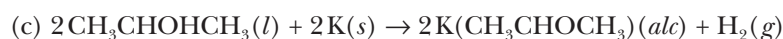
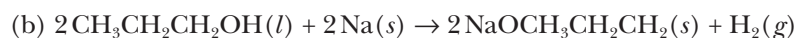
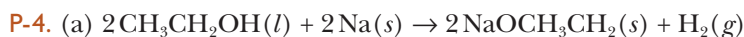
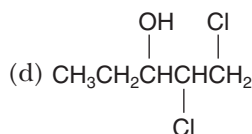
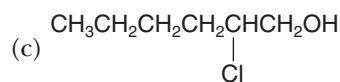
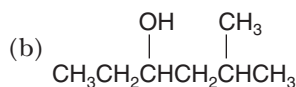
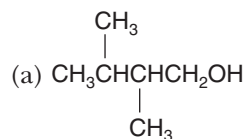
$$m_u = (60.00 \text{ mg}) \left( \frac{3000 \text{ disintegrations} \cdot \text{min}^{-1}}{1200 \text{ disintegrations} \cdot \text{min}^{-1}} \right) - 3.00 \text{ mg} = 147 \text{ mg}$$

Thus, the original 10.00-gram protein sample contained 147 milligrams of threonine.

## Interchapter P

### Alcohols, Aldehydes, and Ketones

P-2. The Lewis formulas are



P-6. The IUPAC names of the aldehydes are

(a) butanal

(b) 3-methylbutanal

(c) propanal

(d) 3,4-dimethylpentanal

**P-8.** The names of the ketones are

- (a) propanone (number not needed)      (b) 3-hexanone  
 (c) butanone (number not needed)      (d) butanone (number not needed)

**P-10.** (a) The formula of ethanal is  $\text{CH}_3\text{CHO}$ , The alcohol to use is  $\text{CH}_3\text{CH}_2\text{OH}$ .

(b) The formula of 2-methylpropanal is  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CHO}$ . The alcohol to use is 2-methylpropanol.

(c) The formula of 2,2-dimethylpropanal is  $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CHO}$ . The alcohol to use is 2,2-dimethylpropanol.

**P-12.** There is only one possible structure for propanone, but there are two for propanol, 1-propanol and 2-propanol.

**P-14.** The number of moles of acetone that reacts is

$$\text{moles of acetone} = (5.00 \text{ mL})(0.792 \text{ g}\cdot\text{mL}^{-1}) \left( \frac{1 \text{ mol acetone}}{58.08 \text{ g acetone}} \right) = 0.0682 \text{ mol}$$

The number of moles of  $\text{CHI}_3(s)$  produced is equal to the number of moles of acetone. The mass of iodoform that would be produced if the yield were 100% (the theoretical yield) is

$$\text{theoretical yield} = (0.0682 \text{ mol CHI}_3) \left( \frac{393.7 \text{ g CHI}_3}{1 \text{ mol CHI}_3} \right) = 26.9 \text{ g}$$

The percent yield is given by

$$\text{percent yield} = \frac{15.6 \text{ g}}{26.9 \text{ g}} \times 100 = 58.0\%$$

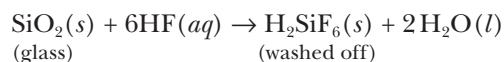
## Interchapter Q The Halogens

**Q-2.** The final equation is the sum of the first two given equations, so

$$K_c = (6.3 \times 10^{-4} \text{ M})(5.1 \text{ M}^{-1}) = 3.2 \times 10^{-3}$$

**Q-4.** Fluorine and chlorine are obtained by electrolysis. Bromine and iodine are obtained by passing chlorine through brines.

**Q-6.** Glass in frosted light bulbs can be etched according to



**Q-8.**  $2\text{NaBr}(s) + 4\text{H}^+(aq) + \text{MnO}_2(s) \rightarrow \text{Mn}^{2+}(aq) + 2\text{Na}^+(aq) + 2\text{H}_2\text{O}(l) + \text{Br}_2(l)$

**Q-10.**  $\text{I}_2(s) + 5\text{H}_2\text{O}_2(aq) + 2\text{KCl}(aq) \rightarrow 2\text{KIO}_3(aq) + 4\text{H}_2\text{O}(l) + 2\text{HCl}(aq)$

**Q-12.** (a)  $\text{I}_3^-$  is an  $\text{AX}_2\text{E}_3$  species and so is linear.

(b)  $\text{IF}_3$  is an  $\text{AX}_3\text{E}_2$  species and so is T-shaped.

(c)  $\text{BrF}_5$  is an  $\text{AX}_5\text{E}$  species and so is square pyramidal.

(d)  $\text{ICl}_4^-$  is an  $\text{AX}_4\text{E}_2$  species and so is square planar.

(e)  $\text{BrF}_6^+$  is an  $\text{AX}_6$  species and so is octahedral.

**Q-14.** The number of millimoles of  $\text{Na}_2\text{S}_2\text{O}_3(aq)$  required is given by

$$\text{millimoles of Na}_2\text{S}_2\text{O}_3 = (4.76 \text{ mL})(0.0100 \text{ M}) = 0.0476 \text{ mmol}$$

The number of millimoles of iodine produced is given by

$$\text{millimoles of I}_2 = (0.0476 \text{ mmol Na}_2\text{S}_2\text{O}_3) \left( \frac{1 \text{ mmol I}_2}{2 \text{ mmol Na}_2\text{S}_2\text{O}_3} \right) = 0.0238 \text{ mmol}$$

The number of millimoles of  $\text{CO}(g)$  that reacted is given by

$$\text{millimoles of CO} = (0.0238 \text{ mmol I}_2) \left( \frac{5 \text{ mmol CO}}{1 \text{ mmol I}_2} \right) = 0.119 \text{ mmol}$$

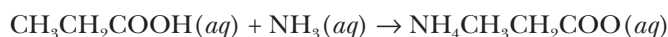
The number of milligrams of  $\text{CO}(g)$  in the air sample is given by

$$\text{mass of CO} = (0.119 \text{ mmol CO}) \left( \frac{28.01 \text{ mg CO}}{1 \text{ mmol CO}} \right) = 3.33 \text{ mg}$$

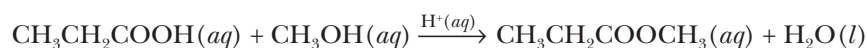
### Interchapter R Carboxylic Acids

- R-2.** (a) 3-chlorobutanoic acid  
 (b) 2,2-dimethylpropanoic acid  
 (c) 4-chloro-3-methylpentanoic acid  
 (d) 3,3,4,4,4-pentachlorobutanoic acid

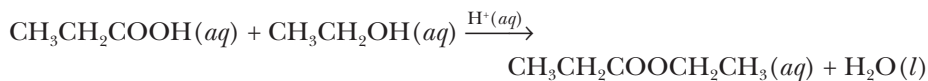
**R-4.** (a) This is a neutralization reaction. The balanced equation is



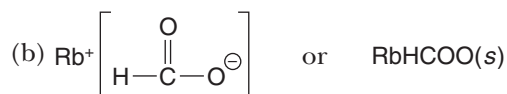
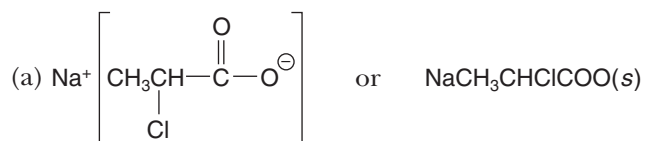
(b) The reaction between an acid and an alcohol yields an ester. The balanced equation is

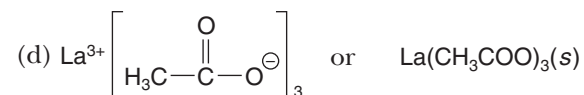
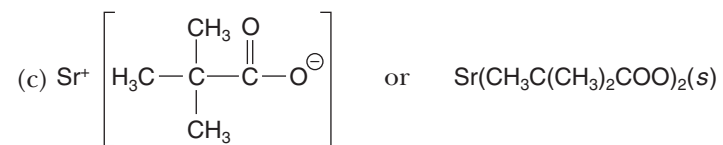


(c) The reaction between an acid and an alcohol yields an ester. The balanced equation is

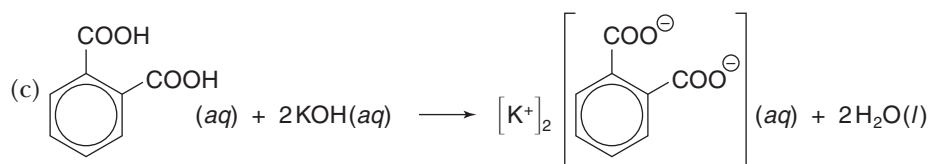
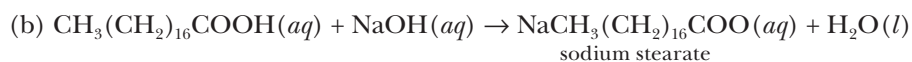
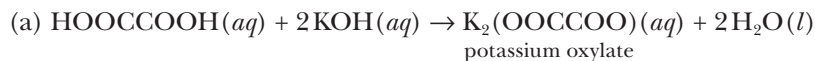


**R-6.** The Lewis formulas and the condensed formulas are





**R-8.** Each of these reactions is the neutralization reaction between a carboxylic acid and a base to yield a salt.

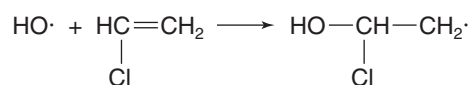


### Interchapter S Synthetic Polymers

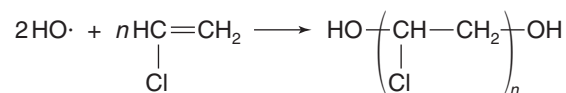
**S-2.** Cross linking holds the polymer chains together and thus makes it more rigid.

**S-4.** Both the dicarboxylic acid and diamine of nylon 66 contain six carbon atoms.

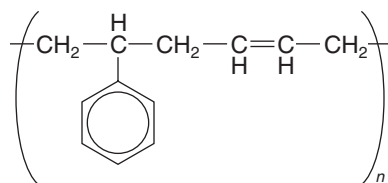
**S-6.** The formation of polyvinyl chloride from chloroethylene is an addition reaction. Taking  $\text{HO}\cdot$  as the radical initiator, the first step in the reaction can be described by



The overall reaction equation is



**S-8.** The formula of the copolymer is

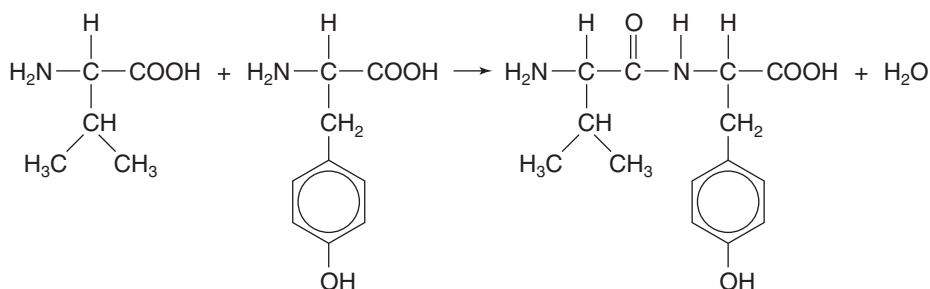
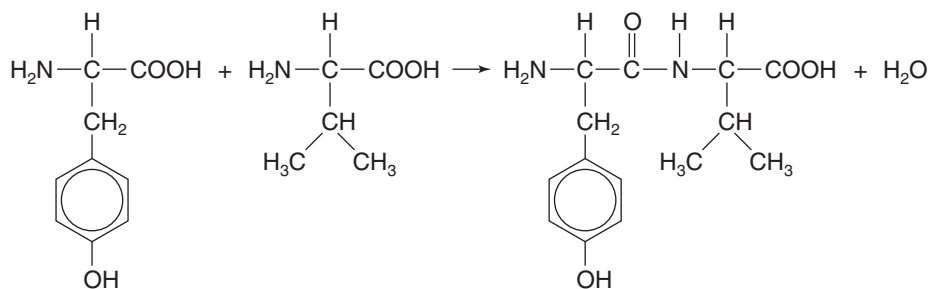


## Interchapter T

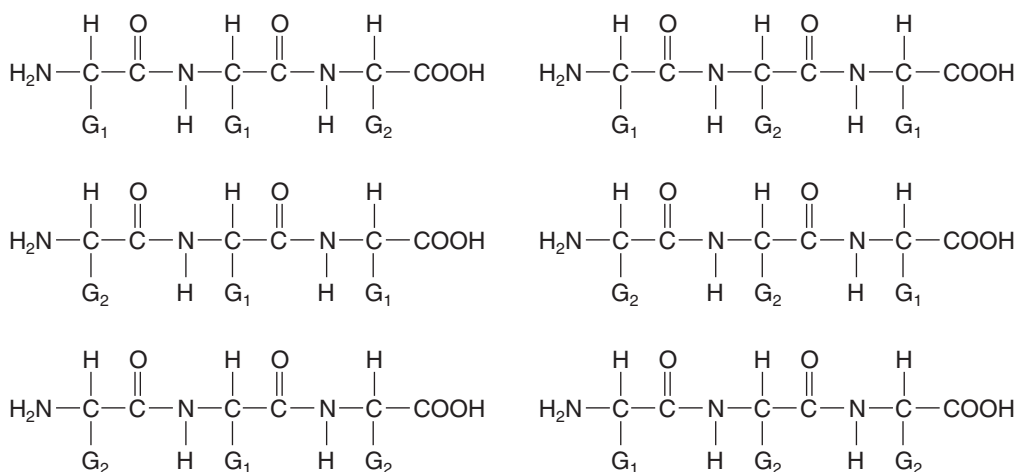
### Biochemical Polymers

**T-2.** The sequence of amino acids in a protein chain is the primary structure. The coiled, helical shape in different regions of a protein is the secondary structure. The overall shape of a protein molecule in water results from an interplay between the amino acid side groups along the protein chain and the solvent, water. This interplay causes the protein to coil, fold, and bend into a three-dimensional shape called the tertiary structure.

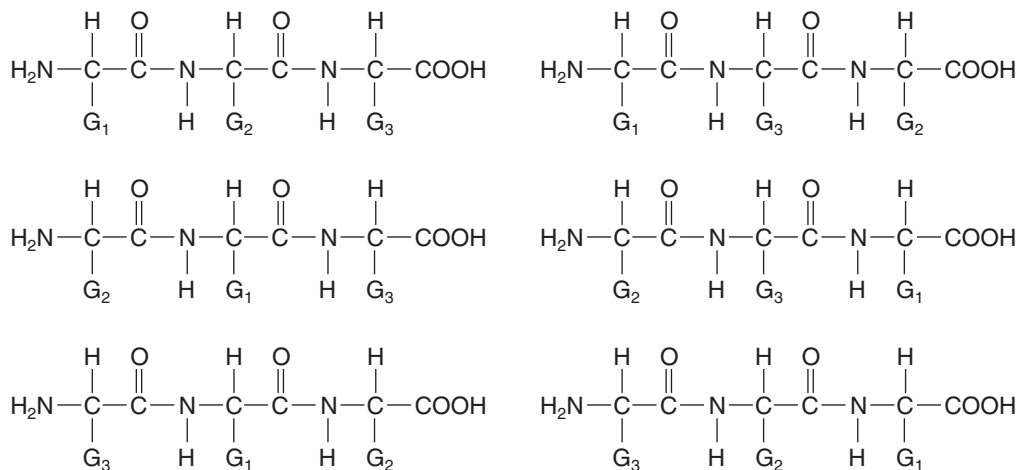
**T-4.** The equations for the reactions between tyrosine and valine are



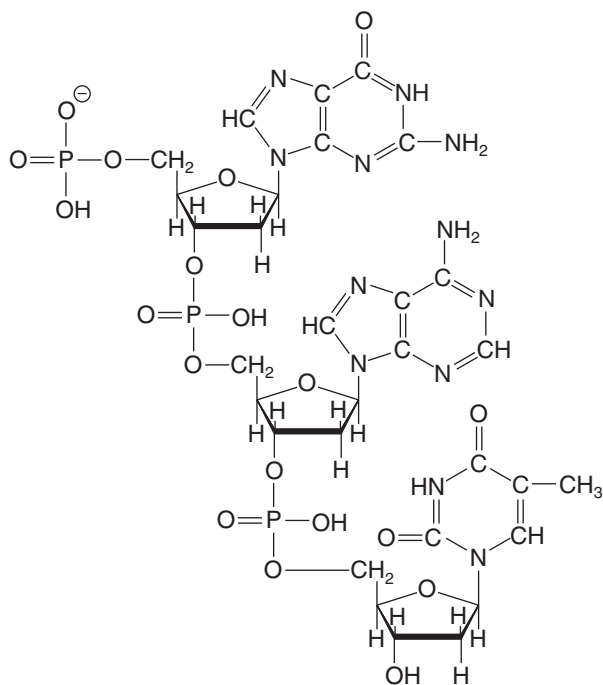
**T-6.** We can form six different tripeptides from two different amino acids. If we represent the side groups of the two amino acids by  $G_1$  and  $G_2$ , then the tripeptides are



We can form six different tripeptides from three different amino acids. If we represent the side groups of the three amino acids by  $G_1$ ,  $G_2$ , and  $G_3$ , then the tripeptides are



T-8. The structural formula is



T-10. We must have T and A opposite each other and G and C opposite each other. The complementary base sequence is



## Interchapter U Batteries

U-2. A primary battery has only one lifetime and cannot be recharged. A secondary battery can be recharged a number of times.

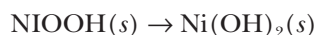
U-4. Nickel-metal hydride batteries have less of a memory effect than do nickel-cadmium batteries and avoid the use of cadmium, a toxic heavy metal.



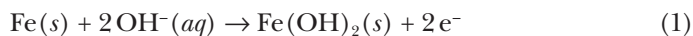
**U-6.** By convention, the oxidation half reaction is written on the left side of the cell diagram and the reduction half reaction on the right side. The unbalanced oxidation half reaction equation is



and the unbalanced reduction half reaction is



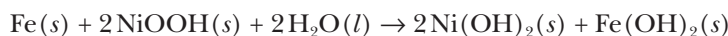
The balanced equation for the anode half reaction (oxidation occurs at the anode) is



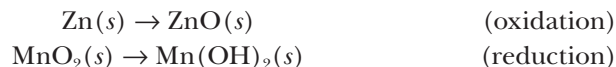
The balanced equation for the cathode half reaction (reduction occurs at the cathode) is



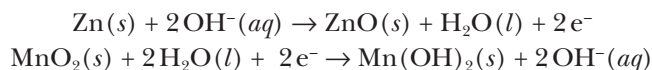
Multiplication of equation 2 by 2 and adding to equation 1 yields the net cell equation



**U-8.** The unbalanced equations for the two half reactions are



The balanced half reaction equations are



Because all the reactants and products in the alkaline manganese cell are in the solid phase, the cell voltage does not depend upon concentration, and so is essentially constant over the life of the cell.

**U-10.** By connecting six 1.5-volt alkaline manganese cells together in series, we get a 9-volt battery.