(b) (No doubt some students will have their own suggestions for simplifying the naming system. Sample answer) The names for esters should reflect the order in which the components are drawn.

7. presence of length of nonpolar hydrocarbon component: $CH_3CH_2CH_2CH_2CH_3$
   double or triple bonds: $CH_2{=}CH_2$, $CH{\equiv}CCH_3$
   OH bonds: CH_3CH_2OH
   NH bonds: H_2NCH_3
   C=O bonds: CH_3CHO, CH_3COOH

Applying Inquiry Skills

8. The products formed are likely to be a mixture of ethylamine, diethylamine, and triethylamine. These amines have different numbers of NH bonds and different numbers of ethyl groups; thus, they have different intermolecular attractions and different melting points and boiling points. The amines can be separated by fractional distillation.

Making Connections

9. The carboxylic acids such as citric acid in lemons and acetic acid in vinegar react with the amines responsible for the fishy taste in fish to produce amides. For example,

$$CH_3COOH + HNCH_3 \rightarrow CH_3CONCH_3 + H_2O$$
$$\qquad\quad\ \ |\qquad\qquad\quad\ \ |$$
$$\qquad\quad CH_3\qquad\qquad CH_3$$

ethanoic acid + dimethylamine → *N,N*-dimethyl ethanamide + water

10. (a) Each small unit must contain an amino group and a carboxyl group, so that an amide bond can form between small units.
    (b) With both amino groups and carboxyl groups, amino acids are likely fairly soluble in water; they are capable of forming strong amide bonds.

1.9 SYNTHESIZING ORGANIC COMPOUNDS

PRACTICE

(Page 82)

Understanding Concepts

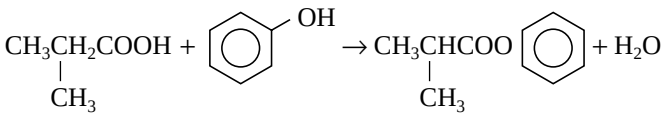
1. (a) $CH_2{=}CHCH_2CH_2CH_3 + H_2O \xrightarrow{H_2SO_4} CH_3CH(OH)CH_2CH_2CH_3$

$$CH_3CH_2CH_2CHO + (O) \rightarrow CH_3CH_2CH_2COOH$$

$$CH_3CH_2CH_2COOH + CH_3CH(OH)CH_2CH_2CH_3 \rightarrow$$
$$CH_3CH_2CH_2COOCHCH_2CH_2CH_3$$
$$\qquad\qquad\qquad\quad|$$
$$\qquad\qquad\qquad CH_3$$

(b) $CH_3CHCH_2OH + (O) \rightarrow CH_3CH_2CHO + H_2O$
$\qquad\quad|\qquad\qquad\qquad\quad|$
$\qquad CH_3\qquad\qquad\quad CH_3$

$$CH_3CHCHO + (O) \rightarrow CH_3CH_2COOH$$
$$\quad|\qquad\qquad\quad|$$
$$CH_3\qquad\qquad CH_3$$



(c) $CH_3CH_2CH_2\underset{\displaystyle OH}{\underset{|}{C}}HCH_2CH_2CH_3 + (O) \rightarrow CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}CH_2CH_2CH_3 + H_2O$

(d) $CH_2{=}CH_2 + H_2O \xrightarrow{H_2SO_4} CH_3CH_2OH$

$CH_3CH_2OH + (O) \rightarrow CH_3CHO + H_2O$

$CH_3CHO + (O) \rightarrow CH_3COOH$

$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$

SECTION 1.9 QUESTIONS

(Page 82)

Understanding Concepts

1. (a) pentyl ethanoate from ethene and an alcohol

$CH_2{=}CH_2 + H_2O \xrightarrow{H_2SO_4} CH_3CH_2OH$
$CH_3CH_2OH + (O) \rightarrow CH_3CHO + H_2O$
$CH_3CHO + (O) \rightarrow CH_3COOH$
$CH_3COOH + CH_3(CH_2)_4OH \xrightarrow{H_2SO_4} CH_3COO(CH_2)_4CH_3 + H_2O$

(b) benzyl ethanoate from an alkene and an alcohol

$CH_2{=}CH_2 + H_2O \xrightarrow{H_2SO_4} CH_3CH_2OH$
$CH_3CH_2OH + (O) \rightarrow CH_3CHO + H_2O$
$CH_3CHO + (O) \rightarrow CH_3COOH$
$CH_3COOH + Ø\text{–}OH \rightarrow CH_3COOØ + H_2O$

(c) 3-octanone from a simpler compound

$CH_3CH_2\underset{\displaystyle OH}{\underset{|}{C}}H(CH_2)_4CH_3 + (O) \rightarrow CH_3\overset{\displaystyle O}{\overset{\|}{C}}H_2C(CH_2)_4CH_3 + H_2O$

(d) methyl benzoate from two alcohols

$Ø\text{-}CH_2OH + (O) \rightarrow Ø\text{–}CHO + H_2O$
$Ø\text{-}CHO + (O) \rightarrow Ø\text{–}COOH$
$Ø\text{-}COOH + CH_3OH \rightarrow Ø\text{–}COOCH_3 + H_2O$

(e) sodium salt of butanoic acid from an ester

$CH_3CH_2CH_2COOCH_3 + NaOH \rightarrow CH_3CH_2CH_2COO^-Na^+ + CH_3OH$

(f) trimethylamine from ammonia and alkanes

$CH_4 + HCl \rightarrow CH_3Cl + H_2$
$NH_3 + CH_3Cl \rightarrow CH_3NH_2 + HCl$
$CH_3NH_2 + CH_3Cl \rightarrow (CH_3)_2NH + HCl$
$(CH_3)_2NH + CH_3Cl \rightarrow (CH_3)_3N + HCl$

(g) *N*-ethyl-ethanamide from an alkane and ammonia

$CH_3CH_3 + HCl \rightarrow CH_3CH_2Cl + H_2$
$CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_2$
$CH_3CH_3 \xrightarrow{\text{catalyst, heat}} CH_2{=}CH_2 + H_2$
$CH_2{=}CH_2 + H_2O \xrightarrow{H_2SO_4} CH_3CH_2OH$
$CH_3CH_2OH + (O) \rightarrow CH_3CHO + H_2O$
$CH_3CHO + (O) \rightarrow CH_3COOH$
$CH_3COOH + CH_3CH_2NH_2 \rightarrow CH_3CONHCH_2CH_3 + H_2O$

2. Controlled oxidation of 1-hexanol, using an oxidizing agent such as $KMnO_{4(aq)}$.

Applying Inquiry Skills

3. (a) 2-methyl-1-butanol + (O) $\rightarrow$ 2-methylbutanal + water
2-methylbutanal + (O) $\rightarrow$ 2-methylbutanoic acid
2-methylbutanoic acid + ethanol $\xrightarrow{H_2SO_4}$ ethyl-2-methylbutanoate + water

(b) **Procedure**

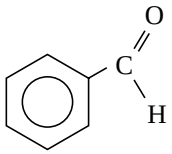
1. Add 2-methyl-1-butanol to an oxidizing agent such as sodium dichromate or potassium permanganate.
2. Add the acid product to an equal amount of ethanol and a few drops of concentrated sulfuric acid.
3. Heat the mixture in a hot-water bath.

Safety Precautions:

Concentrated sulfuric acid is highly corrosive. Avoid contact with skin and clothing. Wear eye protection and a lab apron. 2-methyl-1-butanol is flammable, so there should be no open flames in the vicinity. Dispose of materials in designated labelled containers.

Making Connections

4. (a)



benzaldehyde

(b) CH_3COOCH_2–Ø + NaOH $\rightarrow$ CH_3COONa + Ø–CH_2OH
Ø–CH_2OH + (O) $\rightarrow$ Ø–CHO + H_2O

(c) Hydrogen cyanide poisoning occurs mainly through inhalation, rapidly leading to death in sufficient concentrations. It is a colourless liquid (boiling point 26°C). In the 1980s it was used as a highly toxic chemical warfare agent by Iraq against Iran and the Kurds.

Benzaldehyde (boiling point 179°C) is used primarily as a flavouring chemical and as an intermediate for dyes. It has the odour of almonds, but inhalation may cause coughing, sore throat, and chest pain; high concentrations have a narcotic effect. Ingestion may cause sore throat, abdominal pain, nausea, central nervous system depression, convulsions, and respiratory failure. Skin contact may cause allergic skin reactions.

Natural products are not always healthier than artificial counterparts; many living organisms produce toxins as a system of defence against pests or predators.

5. (a) Drinking tonic water to treat malaria would not be effective. The required dosage is 1800 mg/d (6 $\times$ 300 mg); this is equivalent to drinking 90 cans of tonic water per day. (However, there has been some suggestion that the combination of alcohol with the quinine in tonic water enhances the effects!)

(b) Quinine is water soluble because it contains a hydroxyl group, which allows it to form hydrogen bonds with water molecules.

(c) Malaria has been recorded since 6000–5500 B.C. Quinine, a toxic plant alkaloid from the bark of the Cinchona tree, was used to treat malaria over 350 years ago. Synthetically produced chloroquine was developed in 1934, sold under the names of Resochin and Sontochin, and was later modified and renamed Chloroquine. In 1950, control of malaria was attempted by spraying with DDT to kill the carrier mosquitoes. By the 1960s, chloroquine-resistant strains of malaria appeared, as a result of over usage and under dosage. Quinine was used, as well as a synthetic analogue called mefloquine. Another antimalarial drug, called Qinghaosu, has been used in China for over two thousand years and is effective in treating all forms of malaria.

6. The new career may be in either the organic chemistry field (e.g., plastics, pharmaceuticals) or organically grown foods (e.g., organic farming, organic produce in supermarkets).

7. (Answers will vary but should include reference to several different products, in a variety of categories. Students should refer to claims made on the labels, and discuss the meanings of these claims. Some personal opinions about the uses of these terms should also be presented.)