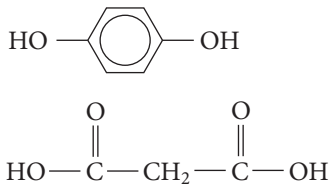
58. polyester



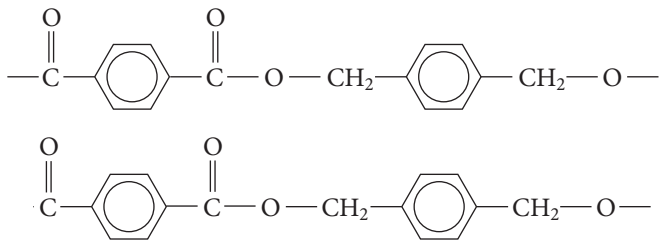
59. First, treat the 1-bromoethane with $NaOCH_2CH_3$ to eliminate the bromine atom and a hydrogen atom resulting in ethene.

$$CH_2BrCH_3 + NaOCH_2CH_3 \rightarrow NaBr + HOCH_2CH_3 + CH_2{=}CH_2$$

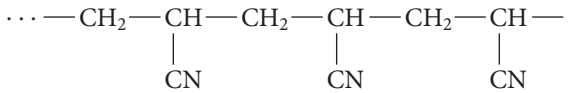
Then carry out addition polymerization on the ethene.

$$n\,CH_2{=}CH_2 \rightarrow \text{- - - }{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}\text{ - - -}$$

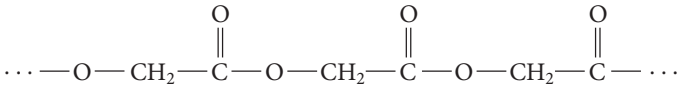
60.



61.



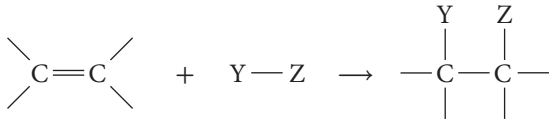
62.



Answers to Chapter 2 Review Questions

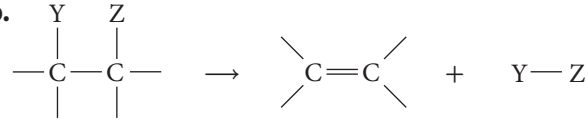
(Student textbook pages 137-41)

1. c
2. d
3. a
4. d
5. d
6. a
7. c
8. b
9. b
10. b
11. a
12. d
13. e
14. a
15. a.



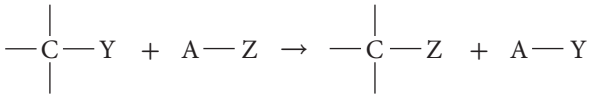
The carbon atoms in the products are bonded to more atoms than the carbon atoms in the reactants.

b.



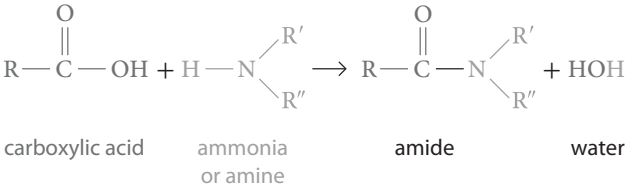
The carbon atoms in the organic product are bonded to fewer atoms than were the carbon atoms in the organic reactant.

c.



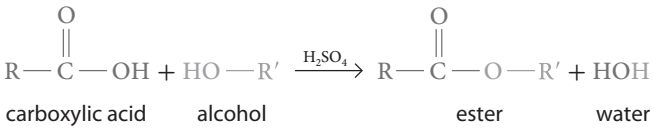
Two compounds react to form two different compounds and the carbon atoms are bonded to the same number of atoms in the product and reactant.

d.



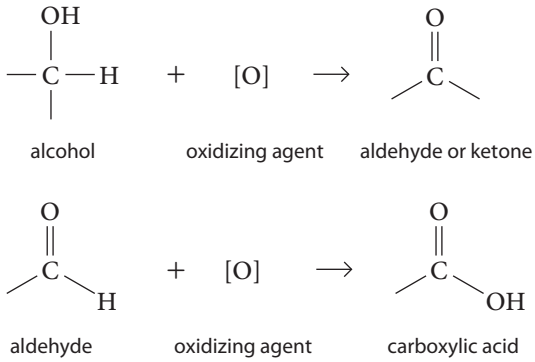
Look for an amide and water molecule as products.

e.



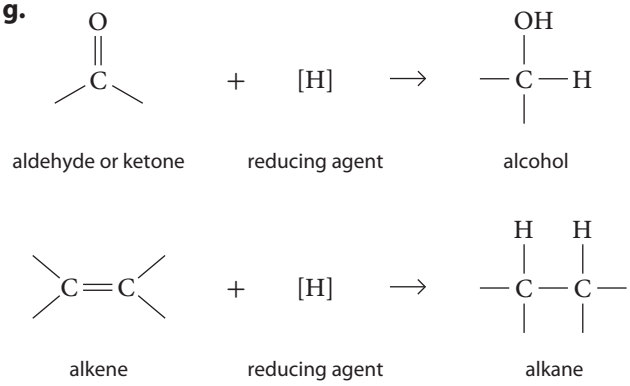
Look for an ester and water molecule as products.

f.



Look for carbon having more bonds to oxygen or fewer bonds to hydrogen.

g.



Look for carbon having fewer bonds to oxygen or more bonds to hydrogen.

h. hydrocarbon + $O_2 \rightarrow CO_2$ + water + energy.

Look for a hydrocarbon chain reacting with oxygen to form carbon dioxide and water.

16. Addition and elimination reactions are the opposite of each other. In addition reaction a double or triple bond between carbon atoms is lost and two new single carbon bonds with new atoms are formed. With elimination reactions two single bonds are lost and a double or triple bond between carbon atoms are formed while two atoms are eliminated from the reactant.

17. During an addition reaction use Markovnikov's rule and add the hydrogen atom to the carbon atom already bonded to the most hydrogen atoms. During an elimination reaction remove the hydrogen from the carbon with the most bonds to other carbon atoms.

18. The reactions result in a large mixture of products. There are other ways to obtain the desired product.

19. Both reactions involve two large molecules coming together to form a large molecule and a small molecule (water). The difference is that esterification reactions always occur between an alcohol and a carboxylic acid. An esterification reaction is a special case of a more general condensation reaction.

20. A molecule is broken apart by adding the hydroxyl group from a water molecule to one side of a bond and the hydrogen atom of the water molecule to the other side of the bond.

21. When naming polymers add poly in front of the name of the monomer unit. In this case the monomer is called propylene (propene).

22. Polymers are long-chain molecules made with repeating units of small molecules and these natural molecules contain repeating units of small molecules. For example, proteins have repeating units of amino acids

23. a. substitution
b. elimination
c. addition
d. substitution
e. addition
f. elimination

24. a. oxidation,
b. reduction,
c. oxidation

25. a. esterification,
b. condensation,
c. hydrolysis

26. polyvinylacetate

27. polyesters – polymers in which the monomers are connected by ester bonds. Typically, one reactant monomer has an alcohol group on both ends and the other reactant monomer has a carboxyl group on both ends.

polyesters and polyamides – Both are made through condensation polymerization reactions using two different monomers. Both use a carboxylic acid monomer as a reactant. Both reactions also produce a small molecule such as H_2O. Both are durable products.

polyamides – polymers in which the monomers are connected by amide linkages. One of the reactant monomers has an amine group on both ends and the other has a carboxyl group of both ends.

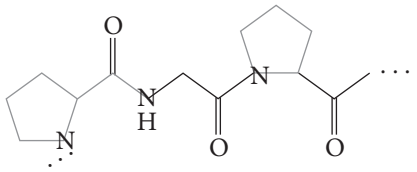
28. a. addition,
b. condensation,
c. addition

29. a. elimination,
b. addition,
c. combustion,
d. substitution

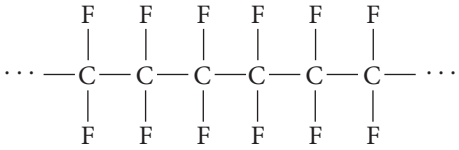
30. a. butan-2-ol
b. major product: 2-bromo-2-methylbutane
minor product: 2-bromo-3-methylbutane
c. propene
d. major product: 3-methylpent-2-ene
minor product: 3-methylpent-1-ene

31. a. propan-1-ol
b. N-ethylpropanamide

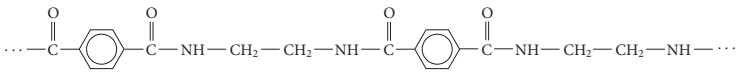
32. a. Both of the compounds have an amine group and a carboxyl group. Any two molecules could react to form an amide bond. Therefore, although they are shown to alternate in the figure below, the two compounds will not necessarily alternate in the polymer.



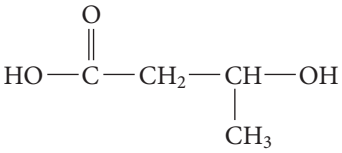
b.



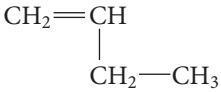
c.



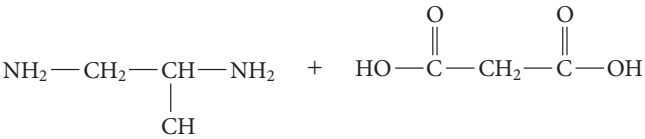
33. a.



b.



c.



34. A polyamide because the functional groups that react to form proteins are a carboxyl group and an amino group which form amide linkages.

35. a. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

b. $2C_2H_5OH + 6O_2 \rightarrow 4CO_2 + 6H_2O$

36. a.
- use 2 fats and 2 oils
- add equal portions of each fat and oil to separate test tubes
- added a measured volume of bromine water to each test tube
- shake gently or warm in a water bath while looking for a decrease in the intensity of the reddish colour of bromine water.

b. $Br_2(aq)$ WHMIS: Corrosive. Harmful if inhaled. Causes respiratory tract irritation and possible burns. Causes eye and skin irritation and possible burns. Wear gloves when making the bromine water. Work in a fume hood.

c. addition

d. $H_3C–CH(Br)–CH(Br)–CH_3$

37.
- heat an alcohol in the presence of H_2SO_4
- react a haloalkane with a strong base such as sodium ethoxide $NaOCH_2CH_3$

38. a. hex-3-ene + HCl

b. 3-methylbutanoic acid + propan-2-ol

c. 2-methylpropan-2-ol + HCl

d. 2,5,-dimethylhex-2,4-diene

e. methane + chlorine

f. 2,3-dimethybutan-2-ol → 2,3-dimethylbutanal

39.
- monomer $CH_3–CH=CH–CH_3$
- polybutene $–[–CH(CH_3)–CH(CH_3)–]_n –$
- solvent alkylethers, tertiary alcohols
- acid catalyst

WHMIS: 2-butene is a gas at room temperature, highly flammable, explosive with air mixture, inhalation can cause dizziness and unconsciousness, evaporation from skin can lead to frostbite, used face shield

40. Major product: 2-bromopropane, $CH_3—CHBr—CH_3$

Minor product: 1-bromopropane, $CH_2Br—CH_2—CH_3$

41. The product, 1-bromopropane, gives the impression that the reaction is a substitution reaction because a bromine atom is seen in place of a hydrogen atom. However, if it was a properly written equation, there would have to be an HBr in the products. Also, this method of substitution with alkanes is nonspecific and there would also be many other products.

42. 2 glucose → maltose + water

43. a. 2-phenylacetic acid + ethanol

b. butyric acid + ethanol

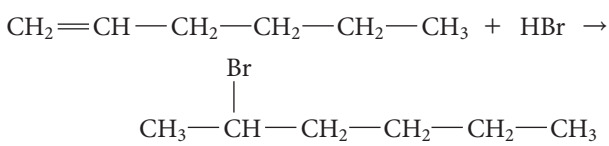
c. ethanoic acid + ethanol

44. Without the alcohol present, the esterification reaction shown will slow down and the reverse hydrolysis reaction will be favoured.

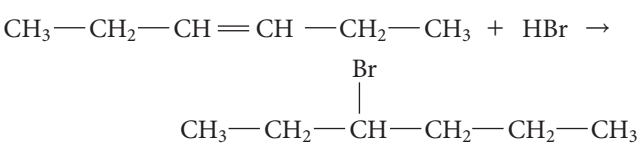
45. Degradable plastics are good because they break down over time when exposed to environmental conditions. It may be difficult to use across the world due to cost of manufacturing

46. Hex-1-ene + HBr →

2-bromohexane + 1-bromohexane



hex-3-ene + HBr → 3-bromohexane



When HBr is added to hex-1-ene the Br can be added to either carbon 1 or 2. Carbon 2 is preferred because it is bonded to the most carbon atoms.

When HBr is added to hex-3-ene the Br can be added to either carbon 3 or 4. However, because the molecule is symmetrical, and carbon atoms are always numbered such that the substituent has the lowest number, adding to either carbon 3 or 4 results in the same product, 3-bromohexane.

47. Some reactions can be categorized as two different reaction names because they fit both descriptions. For example, the reduction of an alkene to an alkane can also be thought of as an addition reaction (hydrogen adding across the double bond)

48. The concept map should include the following types of reactions, with an example of each: addition, elimination, substitution, condensation, esterification, hydrolysis, oxidation, reduction, combustion (complete and incomplete), as well as addition and condensation polymerization. The students should create categories such as "opposites" with examples of hydrolysis and condensation, or oxidation and reduction. They could group reactions with respect to the functional groups involved.

49. Answer can focus on such information as: plastics are made up of long chains so they are flexible so they can be molded into a variety of shapes but may also be hard and rigid and have uses where durability is important. They are used for many everyday products such as water bottles and plastic shopping bags, piping, conduit and their low density and high durability leads to many industrial and construction uses.

50. Refer to Appendix A page 712 SE format for Spider Organizer. The central concept should be the fact that both are polymers found in living systems. Other ideas from brainstorming would include: proteins – monomers are amino acids joined through condensation reactions with amide linkages between the amino acids; include various functions of proteins in the human body such as building of muscle tissue, forming enzymes, hormones. DNA—monomers are nucleotides, forms through condensation reactions of the nucleotides, found in cell nuclei, codes for amino acid sequence to make a protein, controls cell development.

51. The wax candle is made up of very large alkanes. Incomplete combustion of these alkanes results in the formation of the black soot. The black residue on the watch glass is soot which consists of incompletely burned hydrocarbons.

52.

- PET is polyethylene terephthalate, a thermoplastic, polyester
- monomer is ethylene terephthalate made from an esterification reaction between ethylene glycol and terephthalic acid
- repeating unit in the polymer is $C_{10}H_8O_4$
- modification of product is accomplished through a copolymerization reaction e.g. if cyclohexane dimethanol replaces ethylene glycol or if isophthalic acid replaces terephthalatic acid, a softer product is obtained

53. a. One estimate is 400 years.

b. Plastic bags are not part of curbside recycling programs likely because of expense to get rid them. Individuals are reusing more and more.

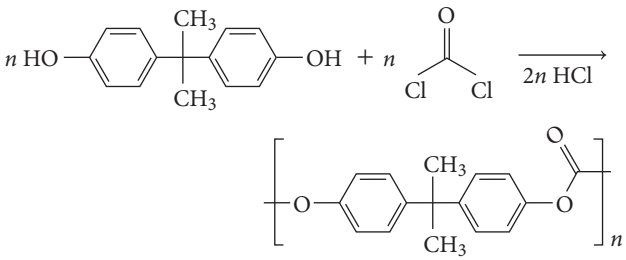
c. Much less plastic waste goes into landfill. It is also more economical.

d. Cleanliness and contamination can be a problem especially if the bag is used for carrying food.

54. Answers can include: recycling of plastic bottles and other plastics in cafeteria; use of dishes rather than use plastics plates when possible; reuse plastic garbage bags; refrigerate left overs in reusable containers rather than covering with plastic wrap, use refillable bottle for water; …and more

55. Students should consult Appendix A, pages 712-14 if they are unsure of which organizer to choose. Alternatively, they could prepare a short audio report, animation, or other type of electronic presentation that covers the topics outlined on page 136 of the student textbook.

56.



BPA mimics human hormones and can have negative neurological effects especially if ingested at a young age. BPA is useful because it makes Polycarbonate plastic, which is clear and nearly shatter-proof.

57. *Note: Assume that the starting material is bromomethane and the product is methyl octanoate.*

Convert bromomethane to methanol through a substitution reaction. Oxidize octan-1-ol to an aldehyde then to the carboxylic acid, octanoic acid. Esterification reaction between methanol and octanoic acid will produce methyl octanoate

$CH_3{-}Br + OH^- \rightarrow CH_3OH + Br^-$

$C_8H_{17}OH + [O] \rightarrow C_7H_{15}CH{=}O \rightarrow + [O] \rightarrow C_7H_{15}COOH$

$C_7H_{15}CH{=}O + [O] \rightarrow C_7H_{15}COOH$

$CH_3OH + C_7H_{15}COOH \rightarrow H_2O + CH_3{-}O{-}CO{-}C_7H_{15}$

58. There is cross linking between strands specifically the formation of hydrogen bonds between N—H and O=C As well there is strength from the aromatic stacking interactions.

59.

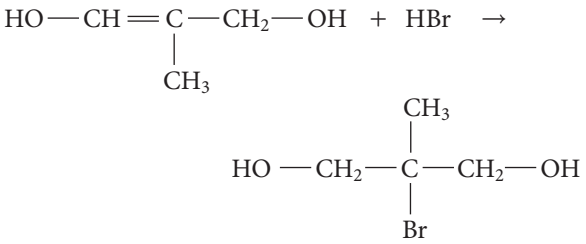
- Carry out an elimination reaction by treating bromoethane with $NaOCH_2CH_3$ to produce ethene.
- Carry out a reduction reaction on propan-2-one to produce propan-2-ol.
- Carry out an elimination reaction by treating propan-2-ol with with sulfuric acid to produce propene.
- Carry out an addition polymerization with the ethene and propene.

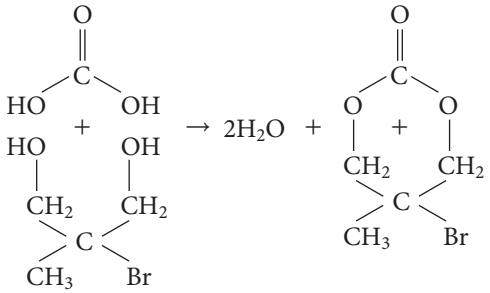
60. a. As the particles become small enough, animals including fish and birds can ingest the plastic. This cannot be digested and can interfere with normal functions in their bodies. Death can result from this or from blockage of airways. Also, further degradation can release harmful chemicals.

b. Reduce, Reuse, Recycle.

61.

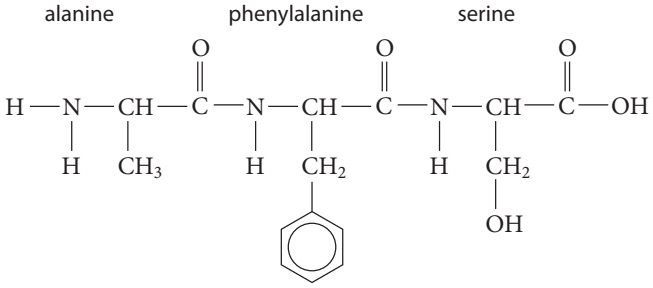
- React the 2-methylprop-1-ene-1,3-diol with HBr to produce 2-bromo-2-methylpropan-1,2-diol, as shown below. There will also be some 1-bromo-2-methylpropan-1,2-diol which will have to be removed.
- React carbonic acid with the 2-bromo-2-methylpropan-1,2-diol to get the final product, also shown below. The second reaction is shown with the compounds shaped so it is clear that the two OH groups on the carbonic acid will react with the two alcohol groups on the 2-bromo-2-methylpropan-1,2-diol.





62. You can use the alcohol of the carboxylic acid you need with the same R group and then oxidize it with an oxidizing agent. You could also find an alkene with a C1–C2 double bond and perform an addition reaction to make it into an alcohol which you can then oxidize

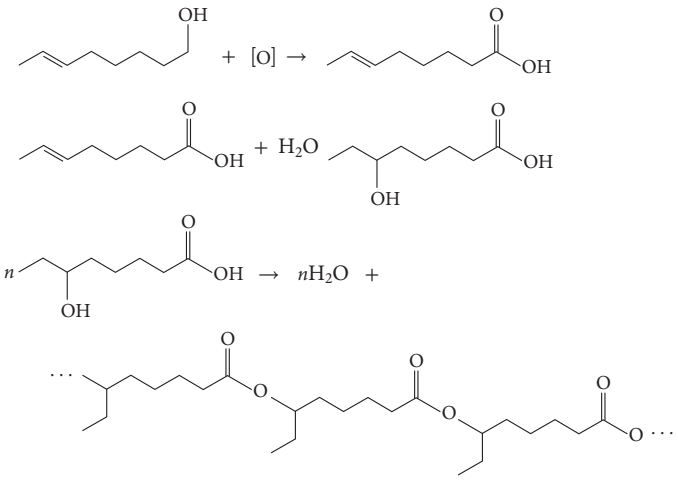
63. For example:



64.

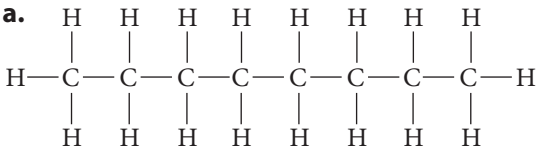
- Oxidize the original oct-6-ene-1-ol to oct-6-eneoic acid
- Carry out an addition reaction with water to convert the oct-6-eneoicacid to 6-hydroxyoctanoic acid.

- Carry out a condensation polymerization reaction to product the poly-6-hydroxyoctanoic acid.



65. Use different coloured paper clips. For example nylon 6,6. The monomers are adipyl chloride and hexamethylene diamine can be represented by different colours or sizes of paper clips.

66. a.



b. $2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(\ell)$

c. CO_2, a major greenhouse gas that is linked to global warming and acid precipitation, is constantly added to the environment. Combustion is usually incomplete, thus adding soot and carbon monoxide to the atmosphere. Also, the octane has additives that can further pollute the air.

Answers to Chapter 2 Self-Assessment Questions (Student textbook pages 142-3)

1. d

2. c

3. b

4. d

5. a

6. e

7. b

8. d

9. b

10. c

11. Amino acids would be found in muscle-building supplements because they are the monomers of proteins which help athletes build muscle. (In reality, only exercise can build muscle.)

12. a. 2-methylpropan-2-yl 2,2-dimethylbutanoate + water,

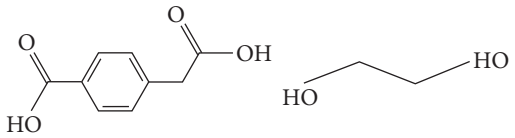
b. *N*-propyl-3-chlorobutanamide + water

13. cycloheptene + $H_2O \rightarrow$ cycloheptanol + [O] $\rightarrow$ cycloheptanone

14. a. addition polymer

$CH_2{=}CH{-}C{\equiv}N$

b. condensation polymer



15. Both cellulose and starch are polymers with glucose as the monomer. However they differ in how the glucose monomers are linked together. Cellulose has beta linkages and starch has alpha linkages. Because of the beta linkages humans cannot digest cellulose; we do not have the enzymes that recognize beta linkages. Cellulose fibers are used to compose wood, paper, cotton and flax. Starch is used as an energy storage unit for plants.

16.
- reduce the carboxylic acid to an aldehyde
- reduce the aldehyde to an alcohol
- an elimination reaction of the alcohol to make an alkene
- add the alkene to itself to perform an addition polymerization reaction

17. a. 2-chloroheptane and 3-chloroheptane; In the reactant, the two carbon atoms involved in the double bond are bonded to an equal number of H atoms and an equal number of C atoms. Therefore, neither product will be preferred.

b. 2-methylhept-3-ene and 6-methylhept-3-ene

Carbon atoms 3 and 5 are bonded to the same number of other carbon atoms as well as the same number of hydrogen atoms. Therefore, neither product is preferred.

18. Essay can focus on common uses such as furniture, cooking utensils, car parts, fabrics, toys, footwear, bags, phones, or computers. If we depended on natural materials for these uses, many applications would not be possible. Also there would not be enough natural products to make items to support the world population.

19. $(CH_3)_2CHCH{=}CHCH_3 + 9O_2 \rightarrow 6CO_2 + 6H_2O$

20. Polyamide. The −COOH of one amino acid reacts with NH_2 of another amino acid to form amide linkages.

21. The number of C−O bonds decrease or the number of C−H bonds increase

22. a. $CH_3CH_2C(Cl){=}CH(Cl)$ and $CH_3CH_2C(Cl)_2{-}CH(Cl)_2$,

b. cyclopentene + water

c. $HO{-}CH_2CH_2CH_3 + Cl^-$

23. butanone + [H] → butan-2-ol
butan-2-ol + HCl → 2-chlorobutane + water

24. a. hexyl propanoate + water,

b. cyclobutanol

25. $HOOC{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}OH$ with H_2SO_4 as a catalyst

The −OH group on one end of the molecule will react with the −COOH group on the other end to form the cyclic compound.

Answers to Unit 1 Review Questions

(Student textbook pages 147-53)

1. c

2. c

3. b

4. b

5. a

6. d

7. b

8. c

9. b

10. e

11. a

12. e

13. a

14. c

15. a. alkene

b. alkane

c. alkene or cycloalkane

d. alkyne

16 a. These are not constitutional (structural) isomers but the same molecule rotated 180 degrees.

b. These are constitutional (structural) isomers, as the longest chain containing the double bond is five carbons long, whereas the second has the longest chain containing the double bond is only four carbons long.

17. Both types of stereoisomers have their atoms bonded in the same sequence on the carbon chain. Cis/trans (Z/E) diastereomers (geometric isomers) have two unique atoms or groups arranged on the same side (cis/Z) or on opposite sides (trans/E) of the double bonds. They have different physical but similar chemical properties. Enantiomers (optical isomers) are non-superimposable mirror images of each other and don't require a double bond. They have essentially the same physical and chemical properties except how the rotate plane-polarized light and react with other enantiomers and with enzymes.

18 a. substitution

b. addition

c. condensation

d. hydrolysis

e. elimination

f. combustion

19. A polymer is a long-chained molecule made up of repeating units. A monomer is the unit which repeats in a polymer. Glucose is a monomer and starch is one of its polymers.

20. Primary amides would be expected to be more soluble in water as they have the greatest number of N–H bonds that allows for hydrogen bonding with H_2O.

21. They are both made through condensation polymerization reactions. Polyamides contain amide linkages, –CO–NH– while polyesters contain ester linkages, –CO–O–.

22. The reactant in an addition reaction is an alkene which must contain a double bond between two carbon atoms. When a small molecule such as HX is added to an asymmetric alkene, two products can form because the X could be added to either of the carbon atoms involved in the double bond. Markovnikov's rule is used to predict which product is more abundant. Also, two different products can form when each double bond has two different atoms or groups of atoms single bonded to it. The products will be *cis* and *trans* isomers.

23. Petrochemicals are products derived from petroleum. Basic hydrocarbons, such as ethene and propene, are converted into plastics and other synthetic materials.

24. a. chloroprene,

b. methyl methacrylate

25. condensation polymerization

26. a. addition

b. condensation

c. combustion

27. a. oxidation

b. reduction

28. a. hydrolysis

b. esterification and condensation

29. a. N-butylethanamide

b. cyclopentylbutanoate

30. a. The longest carbon chain is five carbon atoms long. The correct name is pentane.

b. Numbering of the side groups should give the lowest places on the longest chain for alkanes. The correct name would be 2,3-dimethylpentane.

c. Side groups on an alkane should be placed in alphabetic order excluding multiplying prefixes. The correct name would be 3-ethyl-2,2-dimethylnonane.

d. The benzene group has the greatest number of carbon atoms and therefore would receive the root name. The correct name would be 1-pentylbenzene.

31. a. Aldehydes are always at the end of a carbon chain. The molecule would be a ketone and have the name propanone.

b. Numbering of a cycloalkane would place the halogens in alphabetic order giving the first in the alphabet the lowest number. The correct name would be 1-bromo-2-chlorocyclobutane.

c. The alcohol group would receive the lowest number in the longest chain. The longest carbon chain that does not contain multiple bonds is nine carbons long. The correct name would be 7-methylnonan-3-ol.

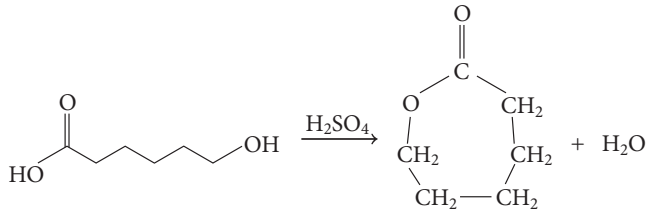
d. The longest carbon chain in an ether gets the root name. The correct name would be ethoxybutane.

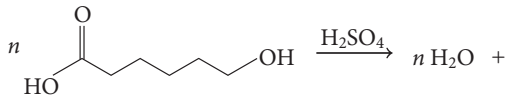
e. The longest unsaturated chain receives the root name. Numbering gives the multiple bond the lowest number. The correct name is 2-ethylpent-1-ene.

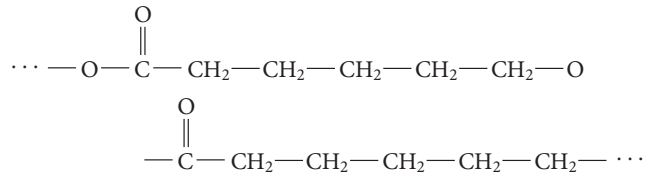
f. The longest carbon chain in the root name is five carbons long. The correct name would be methyl-3-methylpentanoate

32. Use difference in their boiling points, solubility in water and reaction to litmus to distinguish between these molecules. Propyne would have the weakest intermolecular forces (dispersion forces) between molecules and therefore the lowest boiling point and be a gas at room temperature. The gas would have a low solubility in water. Propan-1-ol would both be soluble in water because both can enter into hydrogen bonding. The –COOH group in propanoic acid makes this molecule more polar than the corresponding alcohol and it will have the higher boiling point will be higher than the alcohol. Propanoic acid will turn litmus red.

33. Esterification (cyclic) and polymerization







34.

- Convert ethane to ethene by cracking.
  $CH_3—CH_3 \xrightarrow[800°C]{Pt} CH_2=CH_2 + H_2$
- Convert ethene into ethanol by addition of H_2O.
  $CH_2=CH_2 + H_2O \rightarrow CH_3—CH_2OH$
- Convert ethanol to ethoxy ethane by dehydration. This reaction requires strong sulfuric acid as a catalyst and high temperatures.
  $2CH_3—CH_2OH \xrightarrow[heat]{H_2SO_4} CH_3—CH_2—O—CH_2—CH_3 + H_2O$

35. a. propan-1-ol + ethanol

b. 3-chloro-2,2-dimethylpentane

c. N-methyl-N-(2-methylpropyl)ethanamide

36. a. A is ethane; C is ethanol; B is ethyl ethanoate ; D is ethanoic acid

b. ethane $CH_3—CH_3$; ethanol $CH_3—CH_2—OH$; ethyl ethanoate $CH_3—CH_2—CO—O—CH_2—CH_3$; ethanoic acid $CH_3—COOH$

37. a. Both molecules have aromatic (benzene) rings and halogens.

b. Both names contain the name phenyl which is benzene ring, the prefix bi- which indicates that there are two benzene rings, and the name of a halogen.

c. The molecules would be expected to be liquids or solids due to the large number of carbon atoms and highly electronegative halogen atoms there would be significant dispersion forces between molecules.

d. These molecules would not be soluble in water but be soluble in non-polar substances such as hydrocarbons (oils & fats for example).

e. They would be expected to have other similar physical properties such as melting point boiling point density. They may have similar physiological effects since they can dissolve and accumulate in fat tissue

38. an ether

39. Carry out a substitution reaction of benzene with bromine.

benzene + $2Br_2$ →1,3-dibromobenzene + HBr

40. a. 7-methylocta-2,6-dien-1-ol

b. It would be a volatile liquid at room temperature. It would be slightly soluble in polar solvents and very soluble in non-polar solvents.

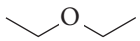
c. Ethanol would be a suitable solvent as it would evaporate quickly allowing the geraniol to slowly volatilize.

41 a. Amino acids have both amino, $–NH_2$, and carboxyl, –COOH, functional groups.

b. Glycine would be named 2-aminoethanoic acid and alanine would be 2-amino-propanoic acid.

c. Glycine would be more soluble in water than alanine as it has fewer alkyl groups.

42. a.



b. It should be a gas at room temperature, be soluble in non-polar solvents and of low solubility in water.

c. Its extreme flammability would be one of the reasons for not being used in operating rooms.

43.

- monomer $CH_3—CH=CH—CH_3$
- polybutene $–[—CH(CH_3)—CH(CH_3)—]_n–$
- solvent alkylethers, tertiary alcohols
- acid catalyst

WHMIS: 2-butene is a gas at room temperature, highly flammable, explosive with air mixture, inhalation can cause dizziness and unconsciousness, evaporation from skin can lead to frostbite, use face shield

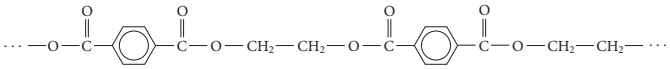
44. a. butanal, butanoic acid

b. 4-methylhexan-3-ol

45. a. poly-1,1-dichloroethene;

$$\cdots —CH_2— CCl_2—CH_2— CCl_2—CH_2— CCl_2—CH_2— CCl_2— \cdots$$

b. trade name is Dacron



46. a.

- use 2 fats and 2 oils
- add equal portions of each fat and oil to separate test tubes
- added a measured volume of bromine water to each test tube
- shake gently or warm in a water bath while looking for a decrease in the intensity of the reddish colour of bromine water.

b. Br_2(aq) WHMIS: Corrosive. Harmful if inhaled. Causes respiratory tract irritation and possible burns. Causes eye and skin irritation and possible burns. Wear gloves when making the bromine water. Work in a fume hood.

c. addition

d. $H_3C—CH(Br)—CH(Br)—CH_3$

47. Ethanol is the only one of the three that will mix with water. Adding water to each will indicate which one is ethanol. Hex-2-ene can be separated from benzene by the addition of Br_2(aq). The bromine water will discolour as it reacts with the hex-2-ene but will not react with benzene.

48. a. 3-hydroxypropanoic acid

b. 4-aminobutanal

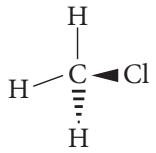
49. butane; 3-methylpentane; 2-chloropentane; 2-iodopentane; 1-bromohexane

50.

- Oxidize the ethanol all the way to ethanoic acid.
- Carry out an addition reaction using HCl with the non-1-en-5-amine to form 2-chloronon-5-amine.
- Carry out a condensation reaction between the ethanoic acid with the 2-chloronon-5-amine in the presence of an acid catalyst to form the amide bond.

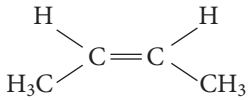
51. The teacher might suggest to the students that they start this question early and carry a list of the classes of compounds for several days or a week. As they are in different locations, they can look for examples. It would be interesting for them to look for a certain category of used (e.g. foods, medications, cleaning solutions) that a particular hydrocarbon or derivative fits into.

-52.

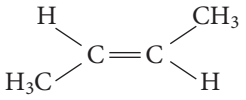


The chlorine atom is above the plane of the paper, one hydrogen atom is below and two hydrogen atoms are in the plane of the paper.

53. The simplest hydrocarbon that can form *cis* and *trans* isomers is 2-butene.

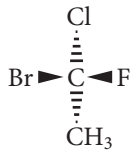


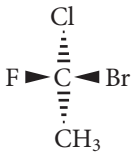
cis-2-butene



trans -2-butene

54.





The diagrams show that 1-bromo-1-chloro-1-fluoroethane can form non-superimposable mirror images of each other. Therefore, there can be enantiomers of 1-bromo-1-chloro-1-fluoroethane.

55. *Sample answer*: Cotton requires large amounts of water to grow and a large amount of pesticides are used on the plant. Polyester uses 10 times more energy than cotton during production and produces 4 times more carbon dioxide

56.

- complete combustion – excess of $O_2(g)$ available; products of complete combustion of hydrocarbons are only carbon dioxide and water.
- complete and incomplete combustion - starting material is a hydrocarbon; CO_2 and H_2O are always produced
- incomplete combustion – insufficient $O_2(g)$ available; less heat given off; in addition to CO_2 and H_2O, CO and C are also products.

Incomplete combustion is dangerous because CO is poisonous, colourless, odourless, gas that is undetectable to our senses.

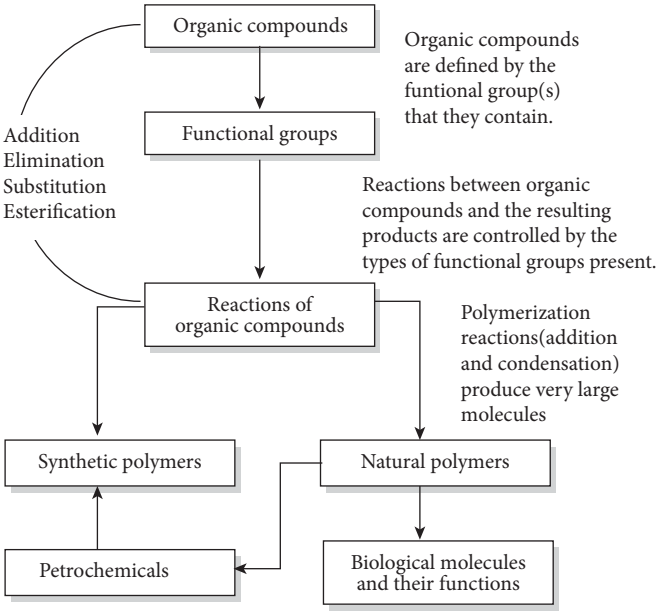
57. Life in the 1800s would centre around providing necessities rather than conveniences. Discuss availability of choices in modes of travel, clothing, furniture, type of work.

58. Students have 58 terms to consider and link; organization will most likely reflect the section organization of the two chapters. Answers should include additional explanatory words to show meaningful relationships between the words and clusters of words.

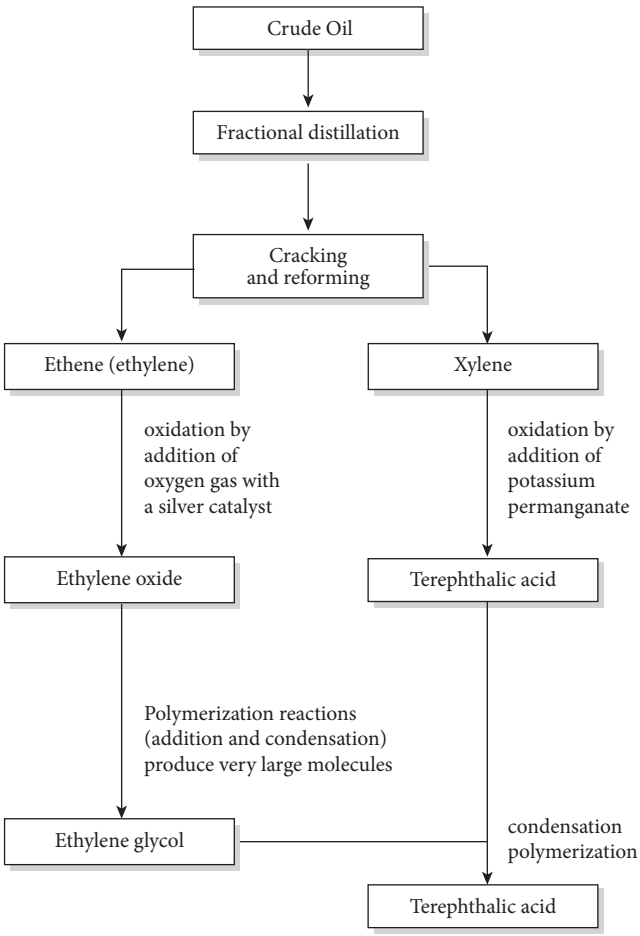
59. Some ideas to expand on: The disposal of items and products made of plastic leads to very large amounts of waste that is harmful to the environment. Since they take a very long time to degrade, they take up space in land disposal sites. No one wants garbage sites near where they live so there are not many places to put this waste. There is a large mass of garbage in the ocean which is mostly made up of plastics. This interferes with marine life and can cause the death of animal life in the ocean. Reuse and recycling are part of the solution to this problem.

60. All aspects of our everyday life have uses of organic compounds. The answer should cover a wide variety of uses and abuses of e.g. pharmaceuticals, plastics, food additives, fuels.

61. One possible flowchart is:



62. One possible flowchart is illustrated below:



63. With respect to solubility, the statement is too general to agree with. The general statement that matches this is that "like dissolves like" Non-polar solvents dissolve non-polar compounds and polar solvents dissolve polar compounds. Water is a polar solvent. Hydrocarbons are non-polar and have low solubility in water while organic compounds with a polar part on the molecule will dissolve in water. The ability to conduct an electric current depends on the presence of ions. Few organic compounds will form ions in solution; even carboxylic acids ionize only slightly. The statement is generally true regarding conductivity.

64. a. Formic acid is the simplest of the carboxylic acids, HCOOH. The IUPAC name is methanoic acid.

b. Human use is to use formic acid as an antibacterial agent and preservative with animal feed; it can be reduced to formaldehyde, a preservative for animal specimens, it can act as a reducing agent to reduce metals from their solutions; it is used in the tanning industry; it is used to synthesize esters.

c. Stinging insects such as bees and beetles will secrete formic acid.

d. It is a defense mechanism to ward off predators.

65. a. Teflon has a very low coefficient of friction and the Teflon polymer is non-reactive to compounds found in foods.

b. At high temperatures, above 240°C, it is known that Teflon breaks down and gives off toxic particles and gases.

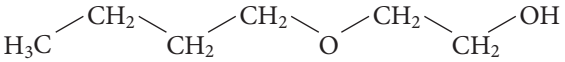
c. A safety note should be included cautioning users to not heat this pan above normal temperatures used for cooking. Do not place in an oven or on a barbeque.

66. a. Any molecule that has a large hydrocarbon chain with polar groups such as alcohols or carboxylic acids on the end would suffice.

b. Emulsifiers make heterogeneous mixtures such with oil and water appear to be homogeneous. For example lecithin in egg yolks helps to prevent the separation of oil and vinegar mixtures in certain salad dressings.

67. Some examples would be pharmacist, medical doctor, researchers in the cosmetics, pesticides and polymer industries, food and drug analyst, petrochemical engineers, hazardous waste handlers as well as a myriad of others. Training for most of these programs would involve a four year undergraduate degree as well as possible post graduate degrees. To become a medical doctor would require at least six years. Only certain schools would offer pharmacy and medical programs

68.



b. One would expect them to be considered flammable and possibly toxic in large doses.

c. The sorbitan molecule contains alcohol, ether, ester and large alkyl functional groups. This combination would make one end of the molecule soluble in water and the other end soluble in the oil.

d. Skimmers recapture the oil which could be reused but require much energy and effort. Burning removes it from the ecosystem but creates greenhouse gases and harms organisms on the surface. The dispersants reduce the concentration of the oil but just spread it and when used underwater may damage the ecosystem deeper than just on the surface. Other benefits and repercussions are possible.

e. Reduce one's use of fossil fuels such as using public transit, recycling plastics, encouraging governments companies to have safeguards in place are just some of the many answers students could give.

69. The chains of this polymer have $-NH_2$ and $-C{=}O$ groups attached, which allows hydrogen bonding to occur. This increases the strength.

70. The greater the intermolecular attractions between molecules the greater the boiling point. The boiling points of benzene and cyclohexane are higher than for hexane because the structure of these two compounds gives a greater surface area. This results in greater intermolecular attractions between their molecules.

71. (1) It is similar to a condensation reaction

(2) reduction,

(3) polymerization

72. The tar-like substance is most likely a long chain carbon compound that is non-polar. Vegetable oil would likely be the best since it has fairly long carbon chains and the esters that make it up are only slightly polar.

73. This is oxidation because a carbon atom in the product is bonded to fewer hydrogen atoms.

74 a. Ethanol or grain alcohol, C_2H_5OH, is the alcohol present in wine, spirits and beer.

b. Due to their ability to form hydrogen bonds, alcohols would be liquids or solids at room temperature.

c. Due to the toxic and combustible nature one would expect the WHMIS symbols for poison and flammable to be on containers used in the workplace

75. Rusting is an oxidation of a metal. The oxidation and reduction discussed in this chapter have organic compounds as reactants.

76. Student answers will likely include some of the following points. The public often believes that "natural" is safer and better than "synthetic," even if the compounds are identical. This is evident in natural and artificial flavourings, and with natural and artificial sweeteners. The public is prepared to pay a premium for "organic" or "natural" products, without knowing or understanding the differences between them. In order for consumers to make informed product choices, they have to thoroughly research the differences between the products. Many manufactured products have strict guidelines around labelling, while there are few if any guidelines around "natural" products.

77. a. With so many organic compounds widely used, solvents have become specific for various classes of compounds. The advantage is that there are no organic compounds for which a solvent cannot be found so that any compound can be cleaned of a surface. The disadvantage is that many organic solvents are volatile and are hazardous to our health if inhaled. Disposal of solvents is another problem since they can persist in the environment for long periods of time.

b. Research should focus on absorption of solvents through the skin and inhalation.

c. Results can be organized, for example, with respect type of health effect, seriousness of health effect, type of solvent

d. Greater care could be taken to avoid using more of the solvent than necessary. Research the type of solvent that will dissolve a particular compound and use the one that has the least effect on health and the environment.

Answers to Unit 1 Self-Assessment Questions

(Student textbook pages 154-5)

1. b

2. e

3. b

4. b

5. e

6. b

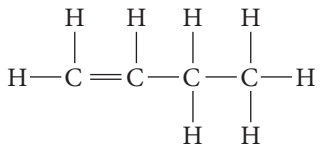
7. d

8. b

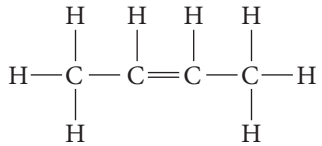
9. b

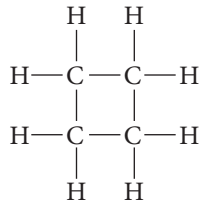
10. a

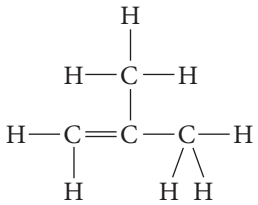
11. There are five structural isomers, one of which has two diasteroisomers.

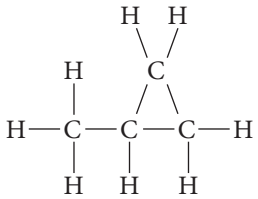


cis or *trans*

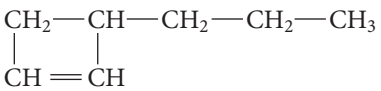




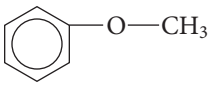




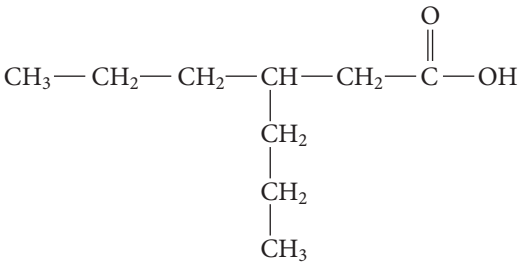
12. a.



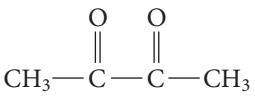
b.



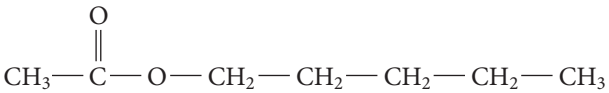
c.



d.

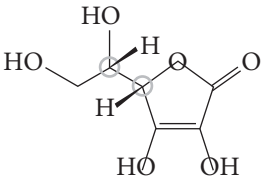


e.



13. Some benefits would be better medicines, dyes, foods, cosmetics, transportation, and agricultural yields. Some drawbacks would be increased reliance on hydrocarbons with the resulting environmental effects such as oil spills and emission of VOCs and ozone destroying CFCs. The release of toxins such as dioxins as well as drugs and pesticides that have had negative side effects on humans and the environment could also be mentioned

14. a. Vitamin C could form enantiomers as it has two carbon atoms that are bonded to four different atoms or groups. These two carbon atoms are circled in the figure below.



b. Due to the large number of hydroxyl groups and oxygen atoms, which could hydrogen bond with other molecules, it would have a high melting point and be a solid at room temperature. Due to the large number of polar hydroxyl groups it would be soluble in water.

c. Yes as fats are non-polar and vitamin C molecules polar, the vitamin C would not dissolve in the fats. It is water soluble and would be quickly eliminated from the body.

15 a. 3-ethyl-2,2-dimethyloctane

b. 1-ethyl-2-fluorobenzene

c. butan-2-ol

d. 3-phenylnonane

16. a. fuels

b. beverages, antiseptics

c. pharmaceuticals

d. sour tasting foods such as vinegar

e. artificial and natural flavourings

These are just some examples of the many places students may find these substances

17. alkane to haloalkane: substitution

haloalkane to alcohol: substitution

alcohol to carboxylic acid: oxidation

18. Molecules must have double bonds to undergo addition polymerization or they must have two functional groups which can react to combine and release a small molecule to undergo condensation polymerization.

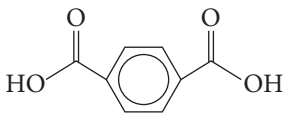
19. The first polymer is an addition polymer and the second is a condensation polymer (polyamide). The polyamide would be stronger because its chains can hydrogen bond to each other.

20. Recycle bags, have a no plastic bag rule, buy degradable garbage bags. Have recycle containers available for soft drink and water bottles.

21. a. 3-methylpentan-2-ol + HCl

b. 3-methylpentan-3-ol and H_2SO_4 as a catalyst

22.



$HO—CH_2—CH_2—OH$

23.

- Oxidize the ethanol first to ethanal and then to ethanoic acid.
- Carry out an addition reaction to add water to the double bond of the but-3-en-2-amine producing 3-aminobutan-2-ol.
- Combine the ethanoic acid and the 3-aminobutan-2-ol and use sulfuric acid as a catalyst to carry out condensation reactions. The carboxyl group of one molecule of ethanoic acid will react with the amino group of the 3-aminobutan-2-ol, and the carboxyl group of a second molecule of ethanoic acid will react with the alcohol group on the other end of the 3-aminobutan-2-ol to form the desired compound.

24. a. major product: 3-bromo-3-methylpentane
minor product: 2-bromo-3-methylpentane

b. 3-methylbutanoic acid and ethanol

c. 2-methylpentan-3-one

25. Small carbon chains ignite too early and explode instead of burn, causing incomplete combustion. This is also damaging to the engine. Carbon chains with more than 12 carbon atoms would not vaporize well enough and would therefore not undergo complete combustion. Soot would build up in the engine and cause damage.