ANSWER KEY

Section Review 25.1

Part A Completion

1. carbon
2. organic
3. covalent
4. Hydrocarbons
5. single
6. Straight-chain
7. branched-chain
8. alkyl
9. hydrocarbon
10. longest

Part B True-False

11. NT
12. AT
13. ST
14. AT
15. ST
16. AT

Part C Matching

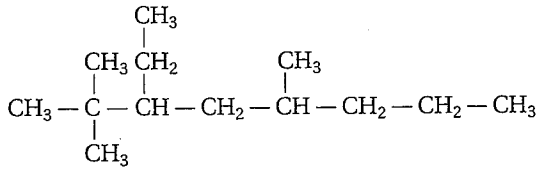
17. d
18. a
19. e
20. f
21. b
22. c

Part D Questions and Problems

23. 2,2-dimethylbutane

24. **a.** 16 **b.** 16

25.



Section 25.2

Part A Completion

1. unsaturated
2. double
3. triple
4. longest
5. double
6. alkane
7. *-ene*
8. double bond
9. *-yne*

Part B True-False

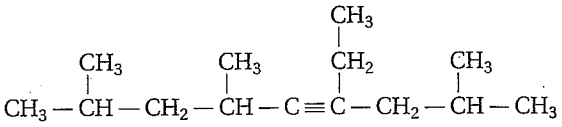
10. NT
11. ST
12. AT
13. ST

Part C Matching

14. a
15. c
16. d
17. b

Part D Questions and Problems

18. 3-methyl-2-hexene
19. 2,3,4,5-tetramethylnonane
20. 4-methyl-1-hexene
21.



Section 25.3

Part A Completion

1. structural
2. molecular
3. structures
4. butane
5. Geometric
6. *cis*
7. *trans*
8. same
9. arrangement
10. asymmetric

Part B True-False

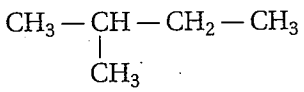
11. NT
12. ST
13. ST
14. AT

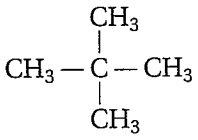
Part C Matching

15. e
16. f
17. b
18. c
19. a
20. d

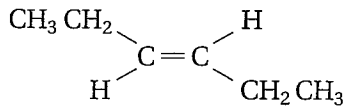
Part D Questions and Problems

21. $CH_3-CH_2-CH_2-CH_2-CH_3$

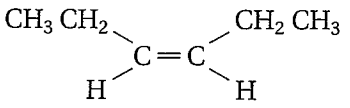




22. Carbon 2 is the asymmetric carbon.

23. 

trans-3-hexene



cis-3-hexene

Section 25.4

Part A Completion

1. arenes
2. benzene
3. resonance
4. cyclic
5. aliphatic
6. Methylbenzene
7. xylenes
8. *ortho, o*
9. *meta, m*
10. *para, p*

Part B True-False

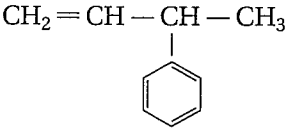
11. ST
12. AT
13. AT
14. AT

Part C Matching

15. d
16. a
17. b
18. c

Part D Questions and Problems

19. 

20. 

21. **a.** cyclooctane
    b. 1,3-diethylbenzene

Section 25.5

Part A Completion

1. natural gas
2. coal
3. methane
4. straight-chain
5. distilling
6. cracked
7. aromatic
8. lignite
9. bituminous
10. anthracite

Part B True-False

11. NT
12. NT
13. AT
14. ST

Part C Matching

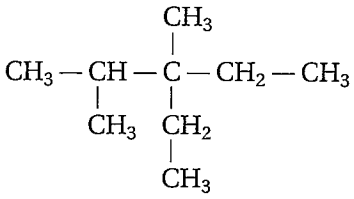
15. b
16. d
17. e
18. c
19. a

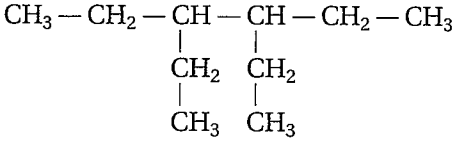
Part D Questions and Problems

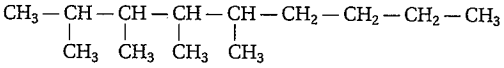
20. $2C_5H_{12}(l) + 11O_2(g) \rightarrow 10CO(g) + 12H_2O(g)$
21. $2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$

Practice Problems

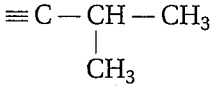
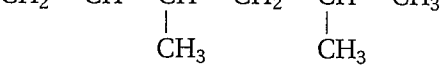
Section 25.1

1. 5-ethyl-3,3,5-trimethyloctane
2. 3-ethyl-2,3,5,5-tetramethylheptane
3. **a.** 

   b. 

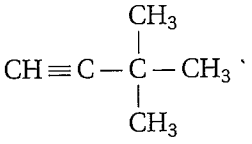
   c. 
4. heptane:
   $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
   octane:
   $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
5. 19

Section 25.2

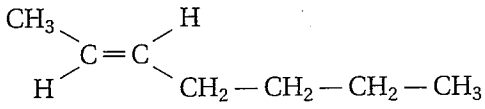
1. 2,4-dimethyl-2-hexene
2. 3,4-dimethyl-1-pentyne
3. 1-pentyne: $CH{\equiv}C—CH_2—CH_2—CH_3$
   2-pentyne: $CH_3—C{\equiv}C—CH_2—CH_3$
   3-methyl-1-butyne:
   
4. **a.** 

b. $CH_2=CH-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$

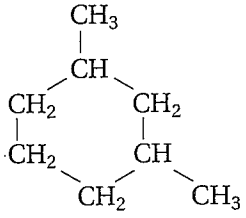
c.

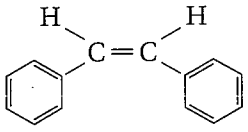


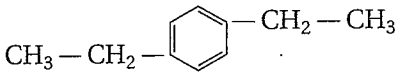
Section 25.3

1. *cis*-2-pentene
2. *trans*-6-methyl-3-heptene
3. 
4. a, d
5. Carbon 3 is the asymmetric carbon.
6. a, c

Section 25.4

1. 1-ethyl-3-methylbenzene
2. 5-phenyl-2-hexene
3. **a.** 

b. 

c. 

Section 25.5

1. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
2. Petroleum contains mainly straight- and branched-chain alkanes with small amounts of aromatic compounds. The refining process yields fractions that differ with respect to the length of the carbon chains. Natural gas contains mainly low molar mass alkanes. Gasoline is composed of alkanes six to twelve carbon atoms long. Kerosene is a fraction composed of alkanes twelve to fifteen carbon atoms long.

Interpreting Graphics 25

1. A
2. C
3. 3,3-dimethylpentane
4. D and F; *cis*-2-pentene and *trans*-2-pentene
5. E; (1-methylpropyl)benzene; C-2 is asymmetric
6. 22
7. 10
8. Compounds A [(1-methylethyl)benzene] and E [(1-methylpropyl)benzene] are aromatic compounds. Each compound contains a benzene ring in its structure.
9. Compounds D and F are geometric isomers, which, like structural isomers, have different physical properties. Thus, the boiling points of compounds D and F are not expected to be the same. In fact, the boiling points of *trans*-2-pentene and *cis*-2-pentene are 36.3 °C and 36.9 °C respectively, a small but measurable difference.

Vocabulary Review 25

1. alkynes
2. substituent
3. *cis* configuration
4. homologous series
5. cracking
6. arenes
7. stereoisomers
8. saturated compounds

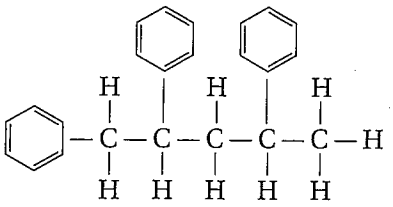
Solution: hydrocarbons

Chapter 25 Quiz

1. ST	5. NT	8. AT
2. NT	6. NT	9. ST
3. NT	7. NT	10. AT
4. AT		

11. 2,5,7-trimethyl-3-octene

12.



Chapter 25 Test A

A. Matching

1. g	5. d	8. e
2. i	6. c	9. j
3. a	7. f	10. b
4. h		

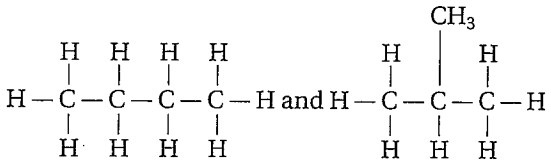
B. Multiple Choice

11. c	16. c	20. a
12. c	17. c	21. c
13. a	18. d	22. c
14. b	19. a	23. b
15. d		

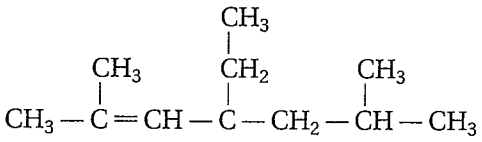
C. Problems

24. 2-methyl-2-phenylbutane

25.



26.



27. $2C_6H_{14}(l) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(l)$

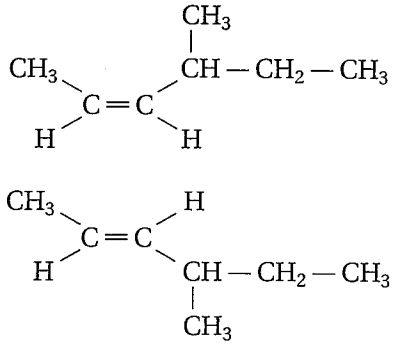
D. Essay

28. 1. Find the root word (ending in *-ane*) in the hydrocarbon name. Then write the longest carbon chain to create the parent structure. 2. Number the carbons of this parent carbon chain. 3. Identify the substituent groups. Attach the substituents to the numbered parent chain at the proper positions. 4. Add hydrogens as needed.

E. Additional Problems

29. Carbon 3 is asymmetric.

30.



F. True-False

31. AT	33. AT
32. AT	34. NT

Chapter 25 Test B

A. Matching

1. b	5. h	8. c
2. i	6. a	9. j
3. f	7. d	10. e
4. g		

B. Multiple Choice

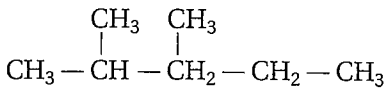
11. d	17. b	23. c
12. c	18. d	24. d
13. b	19. d	25. a
14. b	20. d	26 d
15. c	21. b	27. b
16. d	22. c	28. d

C. True-False

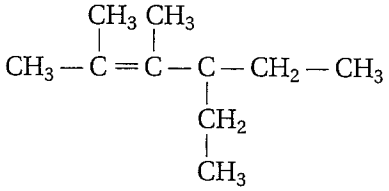
29. AT	33. AT	36. NT
30. AT	34. AT	37. NT
31. NT	35. AT	38. AT
32. AT		

D. Problems

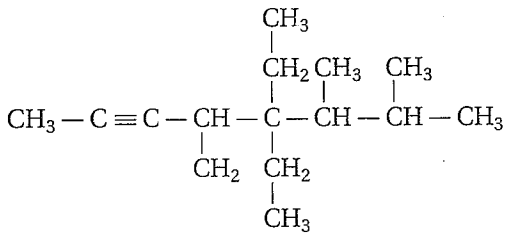
39. a.



b.



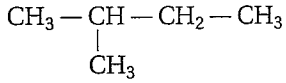
c.



40. a. 3,5-diethyl-4-methylheptane
b. 3-ethyl-2,4,4-trimethyl-2-pentene
c. 6,7-diethyl-2,8-dimethyl-5-propyl-3-decyne

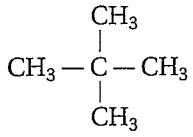
41. a. $CH_3—CH_2—CH_2—CH_2—CH_3$ pentane

b.



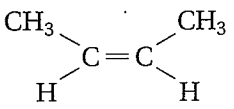
2-methylbutane

c.

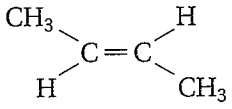


2,2-dimethylpropane

42.



cis-2-butene



trans-2-butene

E. Essay

43. a. hexane C_6H_{14}
$CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

b. 2-hexene C_6H_{12}
$CH_3—CH=CH—CH_2—CH_2—CH_3$

c. 2-hexyne C_6H_{10}
$CH_3—C\equiv C—CH_2—CH_2—CH_3$

The number of hydrogen atoms decreases when carbon atoms form double or triple bonds in the alkene and alkyne, respectively. The number of hydrogen atoms is at a maximum in the unsaturated alkane.

F. Additional Problems

44. Carbon 3 is asymmetric because there are four different groups attached to it—a methyl, an ethyl, and two different forms of propyl groups.

45. a. ethylbenzene

b. 2,3-dimethyl-3-phenylhexane

Section Review 26.1

Part A Completion

1. functional
2. reactive/functional
3. alkenes
4. alkynes
5. Halocarbons
6. substitution
7. hydrogen
8. bromine
9. alcohol
10. salt

Part B True-False

11. AT
12. NT
13. ST
14. AT

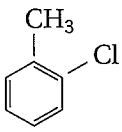
Part C Matching

15. d
16. b
17. a
18. c

Part D Questions and Problems

19. a. hydroxyl
b. carbonyl
c. carbonyl
d. carboxyl

20. a.



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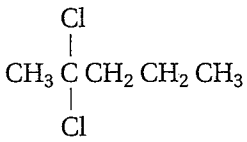


Section Review 26.2

Part A Completion

1. Alcohols
2. primary
3. secondary
4. tertiary
5. secondary
6. hydrogen bonding
7. hydration
8. water
9. hydrogenation
10. alkane
11. ethers
12. lower

Part B True-False

13. AT
14. NT
15. AT
16. NT

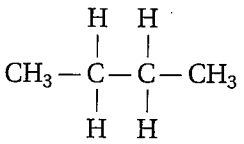
Part C Matching

17. e
18. a
19. d
20. b
21. c

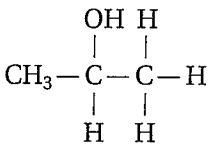
Part D Questions and Problems

22. a. tertiary
b. primary

23. a.



b.



Section Review 26.3

Part A Completion

1. oxygen
2. double
3. ketones/carboxylic acids
4. ketones/carboxylic acids
5. aldehyde
6. carboxylic acid
7. formaldehyde
8. carboxylic acids
9. esters
10. propanol
11. oxidation–reduction
12. potassium dichromate

Part B True-False

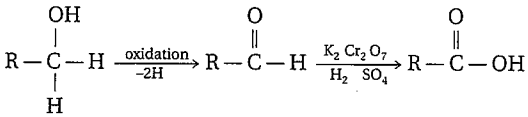
14. AT
15. NT
16. NT
17. AT

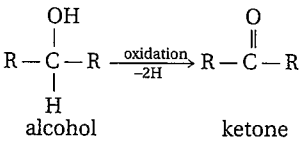
Part C Matching

18. c
19. d
20. e
21. b
22. a

Part D Questions and Problems

23.





24. 3–hexanone

Section Review 26.4

Part A Completion

1. polymer
2. Addition
3. Condensation
4. Polyethylene
5. polyesters
6. length

Part B True-False

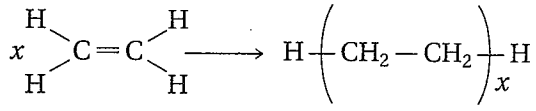
7. ST
8. AT
9. NT
10. AT
11. AT

Part C Matching

12. b
13. c
14. d
15. e
16. a

Part D Questions and Problems

17.



18. Polyesters are polymers consisting of many repeating units of dicarboxylic acids and dihydroxy alcohols joined by ester bonds. Dacron™ is one example of a polyester.

Practice Problems

Section 26.1

1. a. ether
b. carboxyl
c. halogen
d. hydroxyl

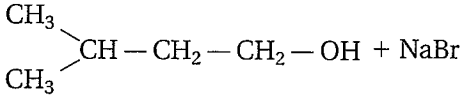
2. They are all halocarbons.

a. *m*-bromobenzene

b. 1-bromo-1-chloroethane

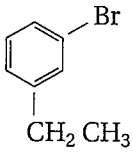
c. chloroethene (vinyl chloride)

3. a.

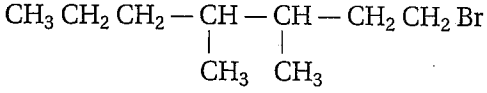


b. $CCl_4 + 4HCl$

4. a.

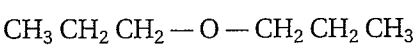


b.

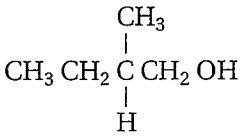


Section 26.2

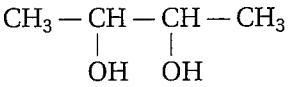
1. **a.** 2-butanol; secondary
   b. ethylphenyl ether
   c. 3-methyl-1-butanol; primary
   d. 1-pentanol; primary
2. dipropyl ether:



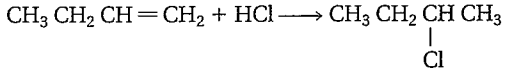
2-methyl-1-butanol:

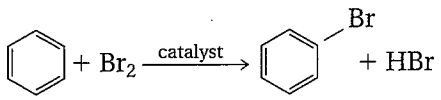


2,3-butanediol:



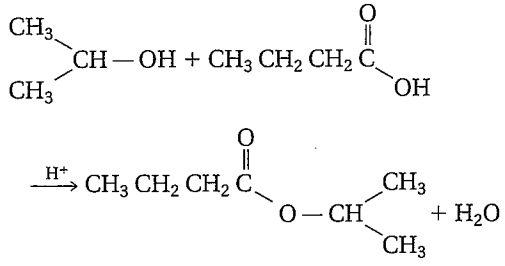
2,3-butanediol is expected to be most soluble due to its two —OH groups, which can form hydrogen bonds with water.

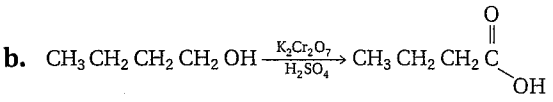
3. **a.** 

   b. 

4. **a.** addition **b.** substitution

Section 26.3

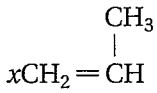
1. **a.** benzaldehyde
   b. 2-butanone
   c. 3-methylpentanoic acid
   d. ethyl butanoate
   e. 3-phenyl-2-propenal
2. **a.** ethanal (acetaldehyde)
   b. propane
   c. 1-butanol
3. **a.** 2-pentanone
   b. octanoic acid
   c. 1-butene or 2-butene
4. **a.** 

   b. 

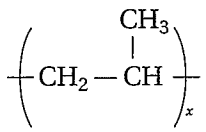
5. **a.** esterification
   b. oxidation-reduction; 1–butanol is oxidized to butanoic acid.

Section 26.4

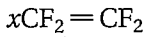
1. propene (propylene)



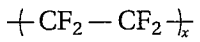
polypropylene



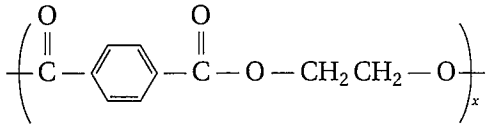
tetrafluoroethene



polytetrafluoroethene (PTFE)



Polypropylene is used extrensively in utensils and containers. Polytetrafluoroethene, also known as Teflon™, is used to coat nonstick cookware and to make bearings and bushings in chemical reactors.

2. 

Polyethylene terephthalate (PET) is formed from the condensation of terephthalic acid and ethylene glycol. One molecule of water is lost for each bond formed. Because the repeating units are joined by ester bonds, PET is a polyester.

Interpreting Graphics 26

1. Only primary and secondary alcohols are oxidized by dichromate ion. Tertiary alcohols, such as 2-methyl-2-propanol, are not expected to react. Table 1 shows a change in absorbance values with time, which indicates a reaction between ethanol, a primary alcohol, and the oxidizing agent. The data in Table 2 show no change even after five minutes. (The slight fluctuation is due to random electronic noise in the instrument.)

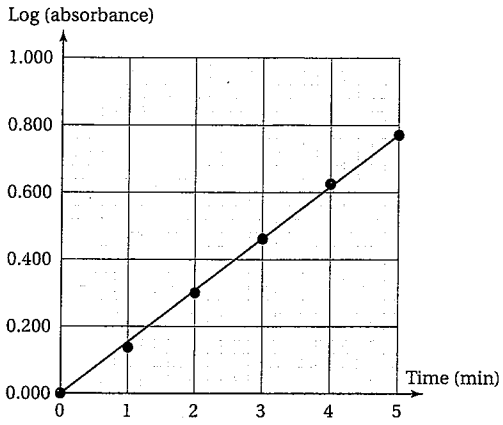
2. This tertiary alcohol serves as a negative control Investigators use negative and positive controls to check that a chemical assay is functioning properly.

3. **a.** $CH_3CH_2OH \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO$

b. $\text{Rate} = \frac{\Delta[CH_3CH_2OH]}{\Delta t} = k \times [CH_3CH_2OH]$

4. **a.** 0.000; 0.140; 0.304; 0.465; 0.627; 0.766

b.



c. Answers will vary slightly.

slope = 0.157 min^{-1}

$0.157\ min^{-1} = \frac{k}{2.303}$

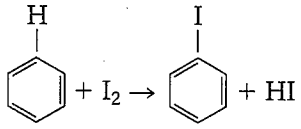
$k = 0.362\ min^{-1}$

Vocabulary Review 26

1. functional group
2. aryl halides
3. substitution reaction
4. alcohols
5. hydration reactions
6. hydrogenation
7. ketones

Solution: aspirin

Quiz for Chapter 26

1. 

2. NT	7. NT	12. AT
3. AT	8. NT	13. AT
4. ST	9. AT	14. AT
5. AT	10. NT	15. AT
6. AT	11. ST	16. ST

Chapter 26 Test A

A. Matching

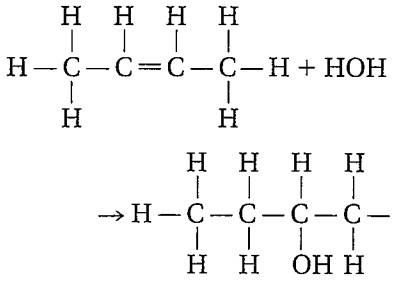
1. e	5. d	8. j
2. i	6. h	9. a
3. f	7. c	10. b
4. g		

B. Multiple Choice

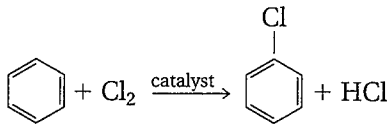
11. b	17. c	23. d
12. c	18. d	24. c
13. a	19. d	25. c
14. b	20. c	26. c
15. d	21. c	27. c
16. a	22. a	

C. Problems

28. **a.**



b.



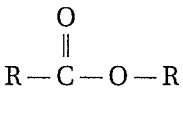
29. **a.** 2-butanol

b. chlorobenzene/phenyl chloride

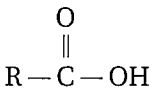
30. **a.** R—X

b. R—O—R

c.



d.



D. Essay

31. Polymers are large, chain-like molecules formed by the covalent bonding of repeating smaller molecules, called monomers. In addition polymerization, unsaturated monomers, such as alkenes, are joined to one another. In condensation polymerization, monomers with two functional groups, such as dicarboxylic acids and dihydroxy alcohols,

react in a head-to-tail fashion. Because of their malleability, high strength-to-weight ratio, and durability, polymers have many commercial uses such as packaging, insulation, and synthetic fibers.

Chapter 26 Test B

A. Matching

1. i
2. a
3. g
4. h
5. j
6. b
7. f
8. d
9. e
10. c

B. Multiple Choice

11. c
12. a
13. b
14. c
15. c
16. c
17. d
18. d
19. c
20. b
21. c
22. b
23. d
24. a
25. c
26. c
27. c
28. b

C. Problems

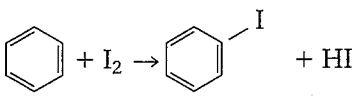
29. **a.** 3–chloro–2–methylpentane
    b. 2,3–dimethyl–2–butanol
    c. butanal
    d. 2–hexanone
    e. propyl ethanoate

30. **a.** aldehyde
    b. ester
    c. alcohol
    d. carboxylic acid
    e. ether
    f. ketone

31. **a.** $CH_3CH_2I + KOH \rightarrow \underset{\text{ethanol}}{CH_3CH_2OH} + KI$

    b. $CH_3—CH_2—CH=CH—CH_2—CH_2—CH_3 + HBr \rightarrow CH_3—CH_2—CHBr—CH_2—CH_2—CH_2—CH_3$

    3–bromohexane

    c.  + HI

    iodobenzene

D. Essay

32. Ethylene glycol is an alcohol with both a high boiling point and a low freezing point due to intermolecular hydrogen bonding. Ethylene glycol is soluble in water. When ethylene glycol is added to the water in a car radiator, the resulting mixture boils at a temperature higher than water alone, and freezes at a temperature lower than water alone. Thus, ethylene glycol protects against boiling in summer and freezing in winter.

Section Review 27.1

Part A Completion

1. prokaryotic/eukaryotic
2. prokaryotic/eukaryotic
3. bacteria
4. green plants
5. organelles
6. Mitochondria
7. lysosomes
8. nucleus
9. Sunlight
10. Photosynthesis
11. oxygen

Part B True-False

12. NT
13. AT
14. AT
15. AT
16. NT

Part C Matching

17. b
18. c
19. a
20. d

Part D Questions and Problems

21. Chloroplasts contain the biological molecules necessary for the conversion of solar energy into chemical energy. Plants store the excess chemical energy in carbon compounds. Like animals, they meet their energy demands by breaking down these stored compounds. These oxidation reactions take place in mitochondria.

Section Review 27.2

Part A Completion

1. Carbohydrates
2. energy
3. cellulose
4. monosaccharides
5. disaccharides
6. polysaccharide
7. starch
8. glucose
9. Glycogen
10. liver

Part B True-False

11. NT
12. AT
13. AT
14. AT
15. ST

Part C Matching

16. e
17. b
18. c
19. a
20. d

Part D Questions and Problems

21. Starches are a source of energy for plants. Cellulose is used by plants to construct cell walls that are hard and rigid.
22. glucose and fructose
23. The hydroxyl group, $-OH$.

Section Review 27.3

Part A Completion

1. amino acid
2. side-chain group
3. side-chain group
4. peptide
5. peptide
6. water
7. protein
8. catalysts
9. enzymes

Part B True-False

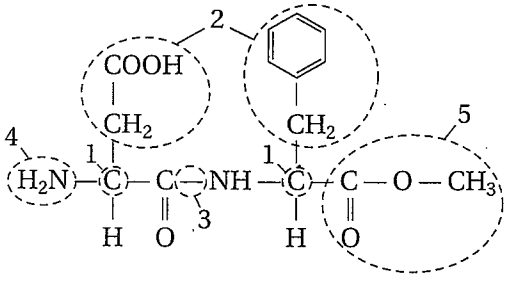
10. ST
11. AT
12. AT
13. AT

Part C Matching

14. b
15. a
16. c

Part D Questions and Problems

17.



Section Review 27.4

Part A Completion

1. lipid
2. not soluble/insoluble
3. triglycerides
4. Triglycerides
5. Saponification
6. glycerol
7. Phospholipids
8. hydrophilic/polar
9. hydrophobic/nonpolar
10. lipid bilayer
11. Cell membranes

Part B True-False

12. AT
13. NT
14. AT
15. AT
16. ST

Part C Matching

17. d
18. b
19. c
20. a

Part D Questions and Problems

21. Wax coats on the surface of plant leaves protect against water loss and attack by microorganisms. In animals, waxes coat the skin, hair, and feathers, which keep these structures pliable and waterproof.
22. The molecules of both types of lipids have hydrophilic and hydrophobic ends. Thus, both types of lipids can interact with polar and nonpolar phases simultaneously. The cleansing action of soaps relies on this physical property.

Section Review 27.5

Part A Completion

1. nucleotide
2. deoxyribonucleic acid
3. ribonucleic acid
4. proteins
5. nitrogen base
6. adenine, guanine, thymine, or cytosine
7. adenine, guanine, thymine, or cytosine
8. adenine, guanine, thymine, or cytosine
9. adenine, guanine, thymine, or cytosine
10. uracil
11. double helix
12. hydrogen bonds
13. thymine
14. cytosine

Part B True-False

15. AT
16. AT
17. ST
18. AT

Part C Matching

19. b
20. e
21. c
22. a
23. d

Part D Questions and Problems

24. Mutations are random changes in the sequence of nucleotides in a DNA molecule. Mutations may arise from additions, deletions, or substitutions of one or more of the nucleotides. When a mutation occurs within a gene, it may stop production of the specified protein or cause production of a protein with an altered amiono acid sequence. Sometimes the change is beneficial; more often, the ability of the protein to function is seriously impaired. For example, a mutation in the peptide chain of hemoglobin reduces its ability to transport oxygen. People with this mutation have a molecular disease called sickle cell anemia, which is named for the distorted shape of the defective red blood cells.

Section Review 27.6

Part A Completion

1. adenosine triphosphate
2. adenosine diphosphate
3. oxidation
4. 30.5 kJ
5. nonspontaneous
6. catabolic or anabolic
7. catabolic or anabolic
8. metabolism
9. catabolism
10. anabolism

Part B True-False

11. AT
12. AT
13. NT
14. AT
15. NT
16. AT

Part C Matching

17. d
18. b
19. c
20. a

Part D Questions and Problems

21. The free energy of ATP hydrolysis is used to drive many nonspontaneous biological reactions. ATP hydrolysis provides the extra energy needed to shift the equilibrium of a nonspontaneous reaction in favor of the products. ATP captures energy from catabolism reactions to drive anabolism reactions.

Interpreting Graphics 27

Part A

1. cytoplasm
2. cell membrane
3. cell wall
4. nucleus
5. cytoplasm
6. cell membrane

Part B

1. The cell in panel **a** represents a prokaryotic cell. It lacks a nucleus and organelles, which are present in eukaryotic cells such as the one depicted in panel **b**. Prokaryotic cells are the cells of bacteria. The cells of all other organisms are eukaryotic.
2. Figure 1a: 0.0001 to 0.001 mm, 0.1 to 1.0 μm, 100 to 1000 nm.

   Figure 1b: 0.001 to 0.01 mm, 1.0 to 10.0 μm, 1000 to 10,000 nm.
3. All of the organelle types labeled in Figure 1b are found in a typical plant cell. Plant cells are eukaryotic.
4. Plant cells contain chloroplasts, structures that enable plants to produce carbohydrates through photosynthesis. Plant cells have cell walls.
5. ATP is produced in the mitochondrion and transported out to the cytoplasm, where it is used to fuel nonspontaneous processes.
6. Mitochondria produce energy needed for cellular activities. Muscle cells are highly active cells, which require many mitochondria to meet their energy demands. Skin cells are less active. They contain significantly fewer mitochondria.
7. Carbohydrates are found in the cytoplasm and are attached to the extracellular surfaces of membrane-bound proteins. They comprise the cell walls, which provide structure and rigidity to plant cells. Because proteins catalyze metabolic reactions, they are found throughout the cell. Proteins embedded in cell membranes help to transport molecules and ions across this barrier. Lipids are found mainly in cell and organelle membranes where they form a barrier to the free flow of ions and molecules into and out of the membrane-enclosed

compartments. DNA, a molecule that stores the information needed to make proteins, is found primarily in the nucleus of eukaryotic cells and in the cytoplasm of prokaryotic cells. RNA, a molecule that participates in the transfer of information between DNA and protein, is found in the cytoplasm of all cells.

Vocabulary Review 27

1. c	5. k	9. i
2. f	6. h	10. d
3. b	7. e	11. a
4. g	8. j	

Quiz for Chapter 27

1. NT	4. AT	7. b
2. AT	5. ST	8. b
3. NT	6. d	9. d

Chapter 27 Test A

A. Matching

1. e	5. c	8. d
2. b	6. f	9. h
3. g	7. a	10. j
4. i		

B. Multiple Choice

11. d	16. d	21. d
12. b	17. a	22. d
13. b	18. c	23. c
14. d	19. c	24. a
15. b	20. b	25. c

C. True-False

26. AT	30. ST	33. NT
27. AT	31. AT	34. AT
28. NT	32. NT	35. AT
29. ST		

D. Questions and Problems

36. Trp-Arg-Ala-Leu-Asn-end

37. **a.** $ATP + H_2O \rightarrow ADP + P_i$

b. $K_{eq} = \frac{[ADP][P_i]}{[ATP]} > 1$

c. spontaneous

38. Phosphorus is essential for the synthesis of phospholipids, nucleic acids, and energy-rich molecules such as ATP. Phosphorus is found in the bloodstream as HPO_4^{2-} and $H_2PO_4^-$, which together form an important buffer. Nitrogen is required for the synthesis of amino acids and nitrogen-containing bases of nucleic acids.

39. Test the aqueous solubility of the substance. Many carbohydrates are soluble in water, whereas lipids are not.

40. Eukaryotic cells contain a nucleus and other membrane-enclosed structures called organelles. Prokaryotic cells do not contain a nucleus or organelles. Eukaryotic cells are typically much larger than prokaryotic cells.

41. **a.** A membrane protein that acts as a channel must have contacts inside and outside the cell membrane. To span the entire bilayer, membrane proteins must have dimensions similar to the observed thickness of the lipid bilayer. The length along the transmembrane axis of the protein must be approximately 5 to 10 nm.

b. Because the lipid bilayer is composed of two sheets of phospholipid molecules arranged tail to tail, each phospholipid molecule must be approximately 2.5 to 5 nm long from head to tail.

E. Essay

42. Nucleic acids are polymers found primarily in cell nuclei. They are composed of nucleotides that contain a phosphate group, a five-carbon sugar, and a nitrogen-containing base. There are two types: DNA and RNA. DNA stores the information needed to make proteins. DNA governs the reproduction and growth of cells. RNA has a key role in the transmission of the information stored in DNA.

Chapter 27 Test B

A. Matching

1. c	5. b	8. e
2. d	6. a	9. h
3. g	7. f	10. j
4. i		

B. Multiple Choice

11. c	16. d	21. d
12. d	17. d	22. b
13. b	18. c	23. c
14. a	19. c	24. c
15. d	20. b	25. d

C. True-False

26. NT	30. ST	33. AT
27. AT	31. AT	34. AT
28. AT	32. AT	35. NT
29. ST		

D. Questions and Problems

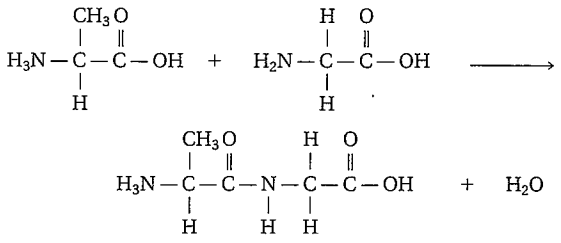
36. More than one answer is possible due to the redundancy of the genetic code. One possibility: 5′ACAGTTGGTACT3′

37. An enzyme catalyzes the conversion of a substrate to product. Doubling and tripling the number of enzyme molecules in the reaction mixture is equivalent to doubling and tripling the number of active sites to which substrate can bind. Thus, when all other conditions are kept the same, the rate at which product is formed will increase with the number of enzyme molecules present in the reaction system.

38. Test the aqueous solubility of the substance. Most proteins are soluble in water, whereas lipids are not.

39. $$2000 \cancel{\text{kJ}} \times \frac{1 \cancel{\text{mol ATP}}}{30.5 \cancel{\text{kJ}}} \times \frac{507.2 \cancel{\text{g}}\ \text{ATP}}{1 \cancel{\text{mol ATP}}} \times \frac{1\ \text{kg}}{10^3 \cancel{\text{g}}}$$
$$= 33.3\ \text{kg ATP}$$

40. Two dipeptides are possible. One possibility:



41. The extent to which the physical properties of a cell membrane are altered by a substance may depend on the solubility of the substance in the lipid bilayer. Beacuase the interior of the lipid bilayer is a hydrophobic environment, nonpolar substances have the greatest chance of becoming incorporated into this protion of the cell membrane.

E. Essay

42. Enzymes are proteins that, like act as biological catalysts. They reduce the time required for a chemical reaction to reach equilibrium, but do not change the normal position of the equilibrium. Enzymes are not changed by the reactions they promote. The molecules on which an enzyme acts are called substrates. In an enzyme-catalyzed reaction the substrate binds to the active site on the enzyme form an enzyme-substrate complex.. Next, bond-breaking and bond-making occur at the active site to produce the products of the reaction. Finally, the products dissociate from the enzyme leaving the enzyme free to bind new substrate and begin a second reaction cycle.

Section Review 28.1

Part A Completion

1. radioactive	9. electrons
2. radioisotopes	10. aluminum foil
3. nuclei	11. Gamma
4. stable	12. visible light
5. radiation	13. mass
6. beta	14. Lead
7. Alpha	15. concrete
8. helium	16. stop

Part B True-False

17. ST	19. AT	21. AT
18. NT	20. NT	

Part C Matching

22. b	24. c	26. d
23. a	25. e	

Part D Questions and Problems

27. a. $^{218}_{84}\text{Po} \rightarrow {}^{4}_{2}\text{He} + {}^{214}_{82}\text{Pb}$

b. $^{210}_{82}\text{Pb} \rightarrow {}^{210}_{83}\text{Bi} + {}^{0}_{-1}e$

Section Review 28.2

Part A Completion

1. band of stability
2. beta
3. positron
4. rate
5. half-life
6. radioactive
7. millions
8. transmutation
9. high-energy
10. atomic numbers
11. synthesized

Part B True-False

12. NT
13. NT
14. AT
15. ST
16. ST

Part C Matching

17. c
18. e
19. b
20. a
21. d

Part D Questions and Problems

22. $\frac{60\text{ hr}}{15\text{ hr}} = 4$ half-lives; After 4 half-lives

    $1/2 \times 1/2 \times 1/2 \times 1/2 = 1/16$ of the original mass will remain. $1/16 \times 18.0\text{ g} = 1.13\text{ g}$

23. $2.0\text{ g} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 0.25\text{ g}$ or 3 half-lives

    42 days ÷ 3 = 14 days

Section Review 28.3

Part A Completion

1. fission
2. neutrons
3. radioisotopes
4. energy
5. moderation
6. absorption
7. fusion
8. heavier
9. energy
10. hydrogen
11. helium

Part B True-False

12. ST
13. NT
14. NT
15. NT

Part C Matching

16. a
17. c
18. e
19. b
20. d

Part D Questions and Problems

21. **a.** 3 **b.** 4

22. **a.** slow fast-moving neutrons so they can be absorbed by the fuel atoms

    b. decrease the number of slow-moving neutrons and slow the chain reaction

Section Review 28.4

Part A Completion

1. ionizing
2. electrons
3. senses
4. Geiger
5. gas
6. beta
7. scintillation
8. all
9. iodine-131
10. phosphorus-32

Part B True-False

11. AT
12. NT
13. ST
14. AT

Part C Matching

15. b
16. e
17. c
18. a
19. d

Part D Questions and Problems

20. c
21. Neutron activation analysis is used to detect trace amounts of elements in samples. Radioisotopes are used to study chemical reactions and molecular structures. Radioisotopes are used to diagnose and treat diseases such as cancer.

Practice Problems 28

Section 28.1

1. The atomic number increases by one; the mass number remains the same.
2. The atomic number decreases by two; the mass number decreases by four.
3. **a.** 28 protons and 36 neutrons

   b. 53 protons and 83 neutrons

   c. 79 protons and 116 neutrons
4. **a.** $^{14}_{7}\text{N}$ **c.** $^{0}_{-1}e$

   b. $^{237}_{93}\text{Np}$

Section 28.2

1. **a.** $^{208}_{87}\text{Fr} \rightarrow {}^{4}_{2}\text{He} + {}^{204}_{85}\text{At}$

   b. $^{7}_{4}\text{Be} + {}^{0}_{-1}e \rightarrow {}^{7}_{3}\text{Li}$

   c. $^{37}_{18}\text{Ar} \rightarrow {}^{37}_{19}\text{K} + {}^{0}_{-1}e$

   d. $^{17}_{9}\text{F} \rightarrow {}^{17}_{8}\text{O} + {}^{0}_{+1}e$

2. **a.** $^{3}_{1}H$ **d.** $^{144}_{58}Ce$
   b. $^{92}_{36}Kr$ **e.** $^{239}_{94}Pu$
   c. $^{30}_{15}P$
3. It takes five half-lives, or 820 s.
   8.0 g→ 4.0 g→ 2.0 g→ 1.0 g→ 0.50 g→ 0.25 g
4. 16 g → 8 g → 4 g → 2.0 g → 1.0 g
   Four half-lives = 4 × 17 days = 68 days
5. $\frac{51 \text{ min}}{5.1 \text{ min}}$ = 10 half-lives. The mass would decrease by a factor of more than 1000.
   $\left(\frac{1}{2}\right)^{10} = \frac{1}{1024}$
6. The mass decreases by a factor of 1/8, or three half-lives. The half-life is 5.49/3 = 183 s

Section 28.3

1. **a.** 2 ([1 + 235] − [90 + 144] = 2)
   b. 3 ([1 + 235] − [87 + 146] = 3)
   c. 4 ([1 + 235] − [72 + 160] = 4)
2. 2.0×10^{7} kcal ÷ 8.0 kcal/g = 2.5×10^{6} g
3. $^{4}_{2}He$

Section 28.4

1. Radioisotopes replace non-radioactive isotopes in the structure of a compound without changing its chemical properties. Tracing the pathways of radioactive isotopes allows scientists to study reaction mechanisms and reaction rates.
2. Teletherapy is the use of gamma radiation to destroy cancerous tissue.

Interpreting Graphics 28

1. 8
2. 6; $^{238}_{92}U \rightarrow {}^{206}_{82}Pb + 8\,{}^{4}_{2}He + 6\,{}^{0}_{-1}e$
3. 8 days = 2 half-lives; $20 \times \frac{1}{2} \times \frac{1}{2} = 5.0$ g
4. 20 minutes = 1 half-life; 1.0 mol = $6.0 \times 10^{23} \times \frac{1}{2} = 3.0 \times 10^{23}$ atoms
5. lead-210; The half-life of polonium-214 is insignificant compared to the half-life of bismuth-214.
6. Three half-lives = 15 days; 16 g → 8 g → 4 g → 2.0 g.
7. For heavier isotopes, such as lead-206, the stability ratio is about 1.5 neutrons to 1 proton. 124 n ÷ 82 p = 1.5
8. Uranium-238 has the longest half-life (4.5×10^{9} yr); polonium-210 has the shortest half-life (1.6×10^{-4} s).

Vocabulary Review 28

1. b	5. i	9. k
2. l	6. d	10. f
3. g	7. e	11. h
4. a	8. c	12. j

Quiz for Chapter 28

1. d	5. a	8. b
2. b	6. d	9. a
3. c	7. c	10. a
4. b		

Chapter 28 Test A

A. Matching

1. a	5. j	8. f
2. i	6. e	9. h
3. g	7. d	10. b
4. c		

B. Multiple Choice

11. b	17. b	22. a
12. c	18. d	23. b
13. b	19. b	24. a
14. b	20. c	25. d
15. a	21. a	26. b
16. c		

C. Problems

27. **a.** $^{42}_{19}K \rightarrow {}^{0}_{-1}e + {}^{42}_{20}Ca$
    b. $^{235}_{92}U \rightarrow {}^{4}_{2}He + {}^{231}_{90}Th$
28. If one-eighth of the sample remains, the isotope decayed through 3 half-lives.
    Three half-lives is 252 days, so one half-life period = 84 days.
    The half-life of scandium-42 is 84 days.
29. 40 days = 5 half-lives.
    $\frac{1}{32}$ of the original sample remains
    = 0.13 gram remaining.

D. Essay

30. The energy released from the sun is the result of a nuclear fusion, or thermonuclear reaction. Fusion occurs when two light nuclei combine to produce a nucleus of heavier mass. In solar fusion, hdrogen nuclei (protons) are fused to make helium nuclei. The reaction requires two beta particles.

$4\,{}^{1}_{1}\mathrm{H} + 2\,{}^{0}_{-1}e \rightarrow {}^{4}_{2}\mathrm{He}$ + energy

Chapter 28 Test B

A. Matching

1. j	**5.** e	**8.** h
2. i	**6.** g	**9.** b
3. c	**7.** a	**10.** f
4. d		

B. Multiple Choice

11. a	**16.** d	**21.** d
12. d	**17.** b	**22.** d
13. c	**18.** a	**23.** d
14. b	**19.** a	**24.** a
15. a	**20.** c	**25.** d

C. Problems

26. **a.** ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$

b. ${}^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}e$

c. ${}^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}e$

27. 27.0 h/6.75 h = 4.00 half-lives

Thus, $12.0\ \mathrm{g} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 0.750\ \mathrm{g}$

28. $\frac{0.125\ \cancel{\mathrm{g}}}{4.00\ \cancel{\mathrm{g}}} = \frac{1}{32}$ of the sample remains

Since $\frac{1}{32}$ represents $\left(\frac{1}{2}\right)^5$, or 5 half-lives,

$\frac{71.5\ \text{years}}{5\ \text{half-lives}} = 14.3\ \text{years/half-life}.$

D. Essay

29. **a.** Chemical reactions occur in an effort to attain stable electron configurations. Nuclear reactions occur in an effort to obtain stable nuclear configurations.

b. Nuclear reactions release far more energy than typical exothermic chemical reactions.

c. Unlike chemical reactions, nuclear reactions are unaffected by changes in temperature, pressure, or the presence of a catalyst.

ANSWER KEY

Section Review 25.1

Part A Completion

1. carbon
2. organic
3. covalent
4. Hydrocarbons
5. single
6. Straight-chain
7. branched-chain
8. alkyl
9. hydrocarbon
10. longest

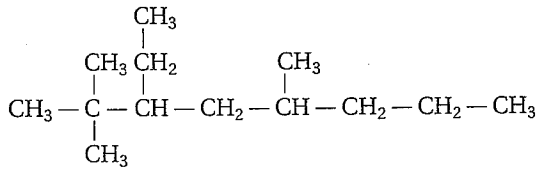
Part B True-False

11. NT
12. AT
13. ST
14. AT
15. ST
16. AT

Part C Matching

17. d
18. a
19. e
20. f
21. b
22. c

Part D Questions and Problems

23. 2,2-dimethylbutane
24. **a.** 16 **b.** 16
25. 

Section 25.2

Part A Completion

1. unsaturated
2. double
3. triple
4. longest
5. double
6. alkane
7. *-ene*
8. double bond
9. *-yne*

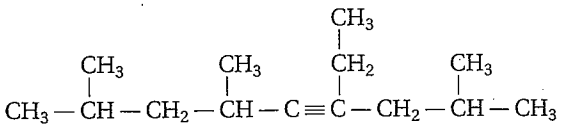
Part B True-False

10. NT
11. ST
12. AT
13. ST

Part C Matching

14. a
15. c
16. d
17. b

Part D Questions and Problems

18. 3-methyl-2-hexene
19. 2,3,4,5-tetramethylnonane
20. 4-methyl-1-hexene
21. 

Section 25.3

Part A Completion

1. structural
2. molecular
3. structures
4. butane
5. Geometric
6. *cis*
7. *trans*
8. same
9. arrangement
10. asymmetric

Part B True-False

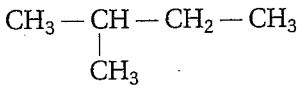
11. NT
12. ST
13. ST
14. AT

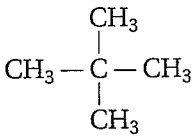
Part C Matching

15. e
16. f
17. b
18. c
19. a
20. d

Part D Questions and Problems

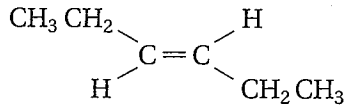
21. $CH_3-CH_2-CH_2-CH_2-CH_3$



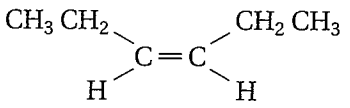


22. Carbon 2 is the asymmetric carbon.

23.



trans-3-hexene



cis-3-hexene

Section 25.4

Part A Completion

1. arenes
2. benzene
3. resonance
4. cyclic
5. aliphatic
6. Methylbenzene
7. xylenes
8. *ortho, o*
9. *meta, m*
10. *para, p*

Part B True-False

11. ST
12. AT
13. AT
14. AT

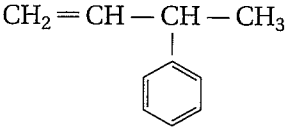
Part C Matching

15. d
16. a
17. b
18. c

Part D Questions and Problems

19.

20.



21. **a.** cyclooctane

b. 1,3-diethylbenzene

Section 25.5

Part A Completion

1. natural gas
2. coal
3. methane
4. straight-chain
5. distilling
6. cracked
7. aromatic
8. lignite
9. bituminous
10. anthracite

Part B True-False

11. NT
12. NT
13. AT
14. ST

Part C Matching

15. b
16. d
17. e
18. c
19. a

Part D Questions and Problems

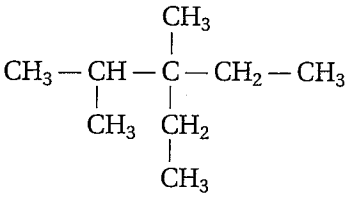
20. $2C_5H_{12}(l) + 11O_2(g) \rightarrow 10CO(g) + 12H_2O(g)$

21. $2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$

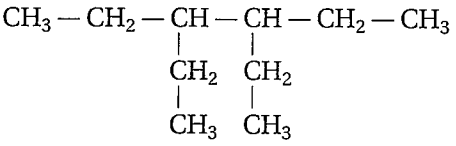
Practice Problems

Section 25.1

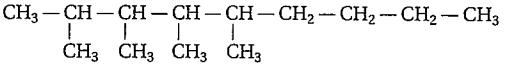
1. 5-ethyl-3,3,5-trimethyloctane
2. 3-ethyl-2,3,5,5-tetramethylheptane
3. **a.**



b.



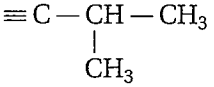
c.



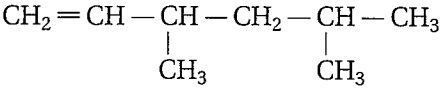
4. heptane:
   $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
   octane:
   $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
5. 19

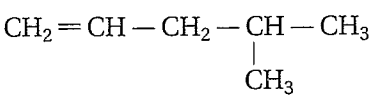
Section 25.2

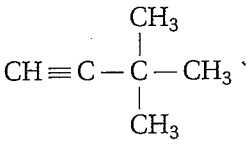
1. 2,4-dimethyl-2-hexene
2. 3,4-dimethyl-1-pentyne
3. 1-pentyne: $CH{\equiv}C—CH_2—CH_2—CH_3$
   2-pentyne: $CH_3—C{\equiv}C—CH_2—CH_3$
   3-methyl-1-butyne:



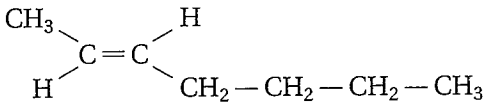
4. **a.**



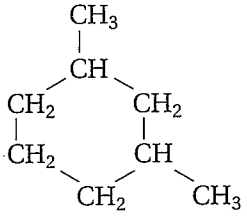
b. 

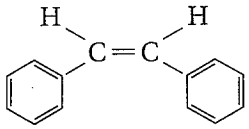
c. 

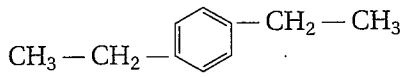
Section 25.3

1. *cis*-2-pentene
2. *trans*-6-methyl-3-heptene
3. 
4. a, d
5. Carbon 3 is the asymmetric carbon.
6. a, c

Section 25.4

1. 1-ethyl-3-methylbenzene
2. 5-phenyl-2-hexene
3. **a.** 

b. 

c. 

Section 25.5

1. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
2. Petroleum contains mainly straight- and branched-chain alkanes with small amounts of aromatic compounds. The refining process yields fractions that differ with respect to the length of the carbon chains. Natural gas contains mainly low molar mass alkanes. Gasoline is composed of alkanes six to twelve carbon atoms long. Kerosene is a fraction composed of alkanes twelve to fifteen carbon atoms long.

Interpreting Graphics 25

1. A
2. C
3. 3,3-dimethylpentane
4. D and F; *cis*-2-pentene and *trans*-2-pentene
5. E; (1-methylpropyl)benzene; C-2 is asymmetric
6. 22
7. 10
8. Compounds A [(1-methylethyl)benzene] and E [(1-methylpropyl)benzene] are aromatic compounds. Each compound contains a benzene ring in its structure.
9. Compounds D and F are geometric isomers, which, like structural isomers, have different physical properties. Thus, the boiling points of compounds D and F are not expected to be the same. In fact, the boiling points of *trans*-2-pentene and *cis*-2-pentene are 36.3 °C and 36.9 °C respectively, a small but measurable difference.

Vocabulary Review 25

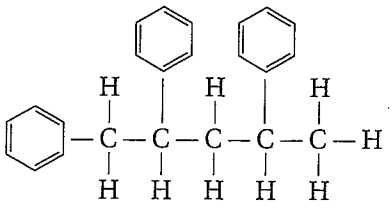
1. alkynes
2. substituent
3. *cis* configuration
4. homologous series
5. cracking
6. arenes
7. stereoisomers
8. saturated compounds

Solution: hydrocarbons

Chapter 25 Quiz

1. ST
2. NT
3. NT
4. AT
5. NT
6. NT
7. NT
8. AT
9. ST
10. AT
11. 2,5,7-trimethyl-3-octene

12.



Chapter 25 Test A

A. Matching

1. g	5. d	8. e
2. i	6. c	9. j
3. a	7. f	10. b
4. h		

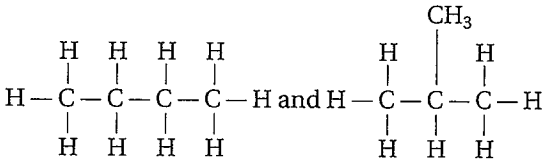
B. Multiple Choice

11. c	16. c	20. a
12. c	17. c	21. c
13. a	18. d	22. c
14. b	19. a	23. b
15. d		

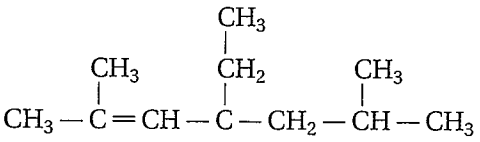
C. Problems

24. 2-methyl-2-phenylbutane

25.



26.



27. $2C_6H_{14}(l) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(l)$

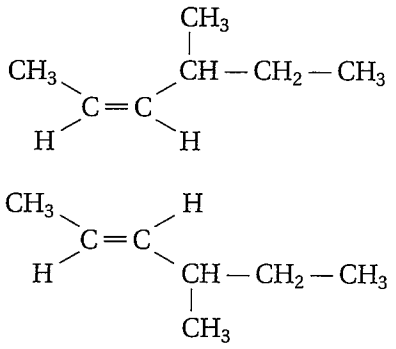
D. Essay

28. 1. Find the root word (ending in *-ane*) in the hydrocarbon name. Then write the longest carbon chain to create the parent structure. 2. Number the carbons of this parent carbon chain. 3. Identify the substituent groups. Attach the substituents to the numbered parent chain at the proper positions. 4. Add hydrogens as needed.

E. Additional Problems

29. Carbon 3 is asymmetric.

30.



F. True-False

31. AT	33. AT
32. AT	34. NT

Chapter 25 Test B

A. Matching

1. b	5. h	8. c
2. i	6. a	9. j
3. f	7. d	10. e
4. g		

B. Multiple Choice

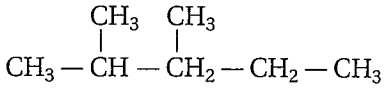
11. d	17. b	23. c
12. c	18. d	24. d
13. b	19. d	25. a
14. b	20. d	26 d
15. c	21. b	27. b
16. d	22. c	28. d

C. True-False

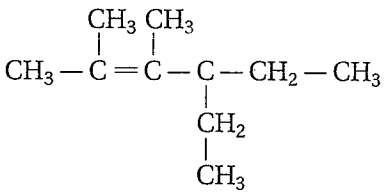
29. AT	33. AT	36. NT
30. AT	34. AT	37. NT
31. NT	35. AT	38. AT
32. AT		

D. Problems

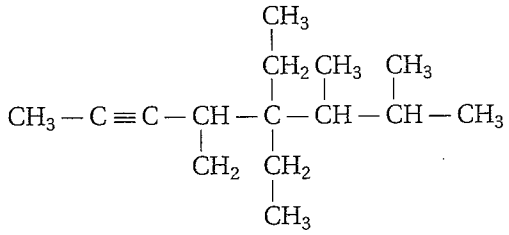
39. a.



b.



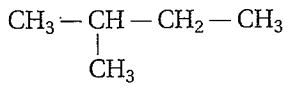
c.



40. a. 3,5-diethyl-4-methylheptane
b. 3-ethyl-2,4,4-trimethyl-2-pentene
c. 6,7-diethyl-2,8-dimethyl-5-propyl-3-decyne

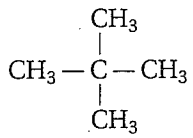
41. a. $CH_3—CH_2—CH_2—CH_2—CH_3$ pentane

b.



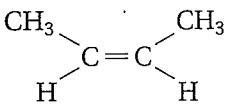
2-methylbutane

c.

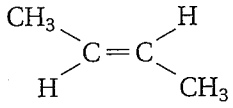


2,2-dimethylpropane

42.



cis-2-butene



trans-2-butene

E. Essay

43. a. hexane C_6H_{14}
$CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

b. 2-hexene C_6H_{12}
$CH_3—CH=CH—CH_2—CH_2—CH_3$

c. 2-hexyne C_6H_{10}
$CH_3—C\equiv C—CH_2—CH_2—CH_3$

The number of hydrogen atoms decreases when carbon atoms form double or triple bonds in the alkene and alkyne, respectively. The number of hydrogen atoms is at a maximum in the unsaturated alkane.

F. Additional Problems

44. Carbon 3 is asymmetric because there are four different groups attached to it—a methyl, an ethyl, and two different forms of propyl groups.

45. a. ethylbenzene
b. 2,3-dimethyl-3-phenylhexane

Section Review 26.1

Part A Completion

1. functional
2. reactive/functional
3. alkenes
4. alkynes
5. Halocarbons
6. substitution
7. hydrogen
8. bromine
9. alcohol
10. salt

Part B True-False

11. AT
12. NT
13. ST
14. AT

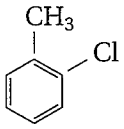
Part C Matching

15. d
16. b
17. a
18. c

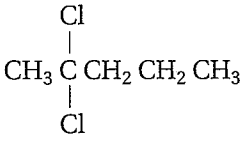
Part D Questions and Problems

19. a. hydroxyl
b. carbonyl
c. carbonyl
d. carboxyl

20. a.



b.



Section Review 26.2

Part A Completion

1. Alcohols
2. primary
3. secondary
4. tertiary
5. secondary
6. hydrogen bonding
7. hydration
8. water
9. hydrogenation
10. alkane
11. ethers
12. lower

Part B True-False

13. AT
14. NT
15. AT
16. NT

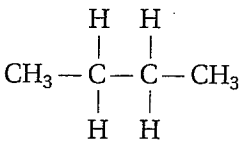
Part C Matching

17. e
18. a
19. d
20. b
21. c

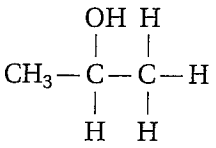
Part D Questions and Problems

22. a. tertiary
b. primary

23. a.



b.



Section Review 26.3

Part A Completion

1. oxygen
2. double
3. ketones/carboxylic acids
4. ketones/carboxylic acids
5. aldehyde
6. carboxylic acid
7. formaldehyde
8. carboxylic acids
9. esters
10. propanol
11. oxidation–reduction
12. potassium dichromate

Part B True-False

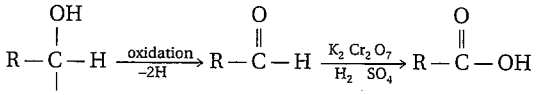
14. AT
15. NT
16. NT
17. AT

Part C Matching

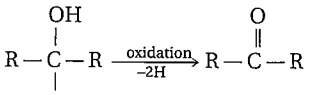
18. c
19. d
20. e
21. b
22. a

Part D Questions and Problems

23.



alcohol — aldehyde — carboxylic acid



alcohol — ketone

24. 3–hexanone

Section Review 26.4

Part A Completion

1. polymer
2. Addition
3. Condensation
4. Polyethylene
5. polyesters
6. length

Part B True-False

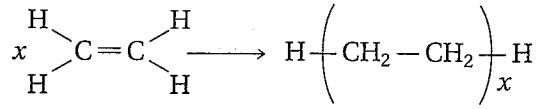
7. ST
8. AT
9. NT
10. AT
11. AT

Part C Matching

12. b
13. c
14. d
15. e
16. a

Part D Questions and Problems

17.

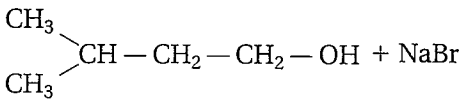


18. Polyesters are polymers consisting of many repeating units of dicarboxylic acids and dihydroxy alcohols joined by ester bonds. Dacron™ is one example of a polyester.

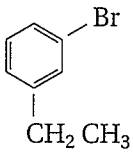
Practice Problems

Section 26.1

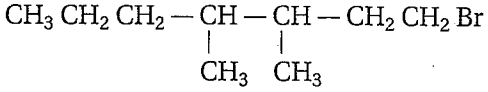
1. a. ether
   b. carboxyl
   c. halogen
   d. hydroxyl
2. They are all halocarbons.
   a. *m*-bromobenzene
   b. 1-bromo-1-chloroethane
   c. chloroethene (vinyl chloride)
3. a.



   b. $CCl_4 + 4HCl$
4. a.

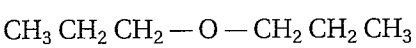


   b.

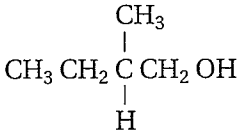


Section 26.2

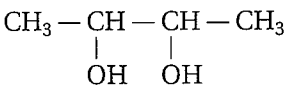
1. **a.** 2-butanol; secondary
   b. ethylphenyl ether
   c. 3-methyl-1-butanol; primary
   d. 1-pentanol; primary
2. dipropyl ether:



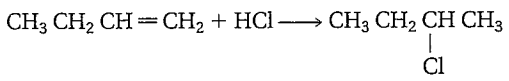
2-methyl-1-butanol:

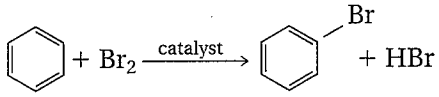


2,3-butanediol:



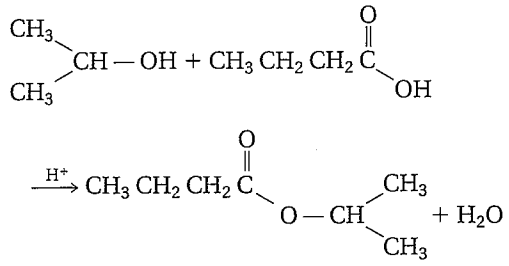
2,3-butanediol is expected to be most soluble due to its two —OH groups, which can form hydrogen bonds with water.

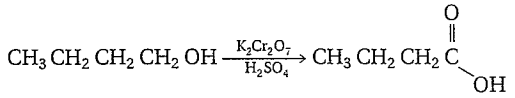
3. **a.** 

   b. 

4. **a.** addition **b.** substitution

Section 26.3

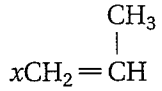
1. **a.** benzaldehyde
   b. 2-butanone
   c. 3-methylpentanoic acid
   d. ethyl butanoate
   e. 3-phenyl-2-propenal
2. **a.** ethanal (acetaldehyde)
   b. propane
   c. 1-butanol
3. **a.** 2-pentanone
   b. octanoic acid
   c. 1-butene or 2-butene
4. **a.** 

   b. 

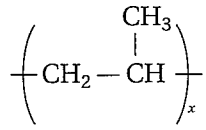
5. **a.** esterification
   b. oxidation-reduction; 1–butanol is oxidized to butanoic acid.

Section 26.4

1. propene (propylene)

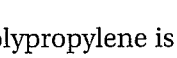


polypropylene

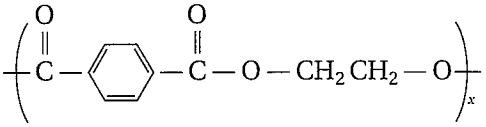


tetrafluoroethene

polytetrafluoroethene (PTFE)



Polypropylene is used extrensively in utensils and containers. Polytetrafluoroethene, also known as Teflon™, is used to coat nonstick cookware and to make bearings and bushings in chemical reactors.

2. 

Polyethylene terephthalate (PET) is formed from the condensation of terephthalic acid and ethylene glycol. One molecule of water is lost for each bond formed. Because the repeating units are joined by ester bonds, PET is a polyester.

Interpreting Graphics 26

1. Only primary and secondary alcohols are oxidized by dichromate ion. Tertiary alcohols, such as 2-methyl-2-propanol, are not expected to react. Table 1 shows a change in absorbance values with time, which indicates a reaction between ethanol, a primary alcohol, and the oxidizing agent. The data in Table 2 show no change even after five minutes. (The slight fluctuation is due to random electronic noise in the instrument.)

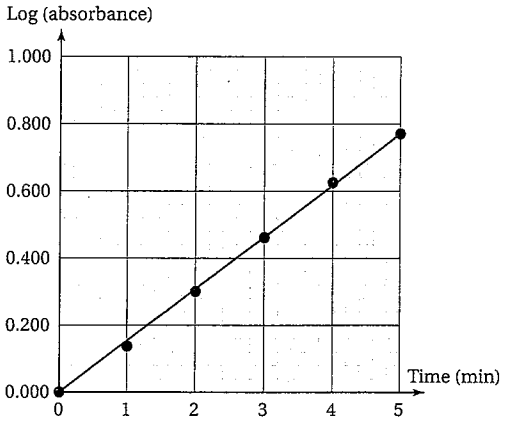
2. This tertiary alcohol serves as a negative control Investigators use negative and positive controls to check that a chemical assay is functioning properly.

3. **a.** $CH_3CH_2OH \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO$

b. $\text{Rate} = \dfrac{\Delta[CH_3CH_2OH]}{\Delta t} = k \times [CH_3CH_2OH]$

4. **a.** 0.000; 0.140; 0.304; 0.465; 0.627; 0.766

b.



c. Answers will vary slightly.

slope = 0.157 min^{-1}

$0.157\ min^{-1} = \dfrac{k}{2.303}$

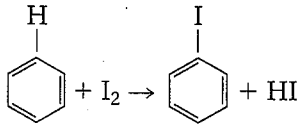
$k = 0.362\ min^{-1}$

Vocabulary Review 26

1. functional group
2. aryl halides
3. substitution reaction
4. alcohols
5. hydration reactions
6. hydrogenation
7. ketones

Solution: aspirin

Quiz for Chapter 26

1. 

2. NT	7. NT	12. AT
3. AT	8. NT	13. AT
4. ST	9. AT	14. AT
5. AT	10. NT	15. AT
6. AT	11. ST	16. ST

Chapter 26 Test A

A. Matching

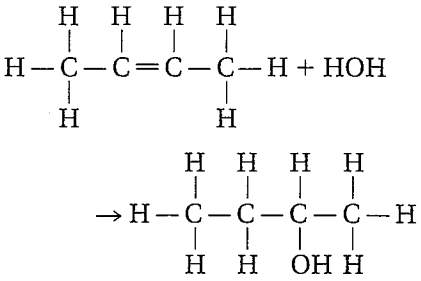
1. e	5. d	8. j
2. i	6. h	9. a
3. f	7. c	10. b
4. g		

B. Multiple Choice

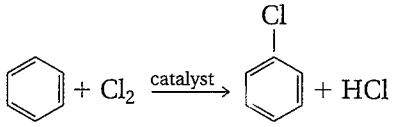
11. b	17. c	23. d
12. c	18. d	24. c
13. a	19. d	25. c
14. b	20. c	26. c
15. d	21. c	27. c
16. a	22. a	

C. Problems

28. **a.**



b.



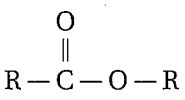
29. **a.** 2-butanol

b. chlorobenzene/phenyl chloride

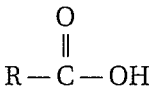
30. **a.** R—X

b. R—O—R

c.



d.



D. Essay

31. Polymers are large, chain-like molecules formed by the covalent bonding of repeating smaller molecules, called monomers. In addition polymerization, unsaturated monomers, such as alkenes, are joined to one another. In condensation polymerization, monomers with two functional groups, such as dicarboxylic acids and dihydroxy alcohols,

react in a head-to-tail fashion. Because of their malleability, high strength-to-weight ratio, and durability, polymers have many commercial uses such as packaging, insulation, and synthetic fibers.

Chapter 26 Test B

A. Matching

1. i	5. j	8. d
2. a	6. b	9. e
3. g	7. f	10. c
4. h		

B. Multiple Choice

11. c	17. d	23. d
12. a	18. d	24. a
13. b	19. c	25. c
14. c	20. b	26. c
15. c	21. c	27. c
16. c	22. b	28. b

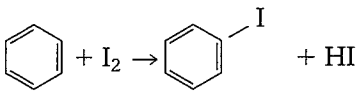
C. Problems

29. **a.** 3–chloro–2–methylpentane
    b. 2,3–dimethyl–2–butanol
    c. butanal
    d. 2–hexanone
    e. propyl ethanoate

30. **a.** aldehyde **d.** carboxylic acid
    b. ester **e.** ether
    c. alcohol **f.** ketone

31. **a.** $CH_3CH_2I + KOH \rightarrow \underset{\text{ethanol}}{CH_3CH_2OH} + KI$

    b. $CH_3-CH_2-CH=CH-CH_2-CH_2-CH_3 + HBr \rightarrow CH_3-CH_2-CHBr-CH_2-CH_2-CH_2-CH_3$
    3–bromohexane

    c.  + HI
    iodobenzene

D. Essay

32. Ethylene glycol is an alcohol with both a high boiling point and a low freezing point due to intermolecular hydrogen bonding. Ethylene glycol is soluble in water. When ethylene glycol is added to the water in a car radiator, the resulting mixture boils at a temperature higher than water alone, and freezes at a temperature lower than water alone. Thus, ethylene glycol protects against boiling in summer and freezing in winter.

Section Review 27.1

Part A Completion

1. prokaryotic/eukaryotic
2. prokaryotic/eukaryotic
3. bacteria
4. green plants
5. organelles
6. Mitochondria
7. lysosomes
8. nucleus
9. Sunlight
10. Photosynthesis
11. oxygen

Part B True-False

12. NT	14. AT	16. NT
13. AT	15. AT	

Part C Matching

17. b	19. a
18. c	20. d

Part D Questions and Problems

21. Chloroplasts contain the biological molecules necessary for the conversion of solar energy into chemical energy. Plants store the excess chemical energy in carbon compounds. Like animals, they meet their energy demands by breaking down these stored compounds. These oxidation reactions take place in mitochondria.

Section Review 27.2

Part A Completion

1. Carbohydrates	6. polysaccharide
2. energy	7. starch
3. cellulose	8. glucose
4. monosaccharides	9. Glycogen
5. disaccharides	10. liver

Part B True-False

11. NT	13. AT	15. ST
12. AT	14. AT	

Part C Matching

16. e
17. b
18. c
19. a
20. d

Part D Questions and Problems

21. Starches are a source of energy for plants. Cellulose is used by plants to construct cell walls that are hard and rigid.
22. glucose and fructose
23. The hydroxyl group, $-OH$.

Section Review 27.3

Part A Completion

1. amino acid
2. side-chain group
3. side-chain group
4. peptide
5. peptide
6. water
7. protein
8. catalysts
9. enzymes

Part B True-False

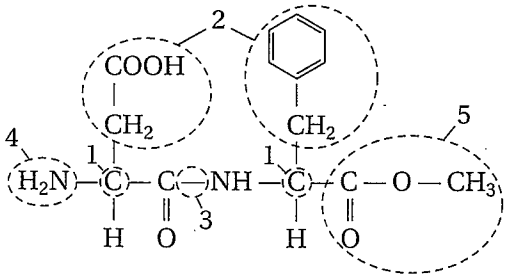
10. ST
11. AT
12. AT
13. AT

Part C Matching

14. b
15. a
16. c

Part D Questions and Problems

17.



Section Review 27.4

Part A Completion

1. lipid
2. not soluble/insoluble
3. triglycerides
4. Triglycerides
5. Saponification
6. glycerol
7. Phospholipids
8. hydrophilic/polar
9. hydrophobic/nonpolar
10. lipid bilayer
11. Cell membranes

Part B True-False

12. AT
13. NT
14. AT
15. AT
16. ST

Part C Matching

17. d
18. b
19. c
20. a

Part D Questions and Problems

21. Wax coats on the surface of plant leaves protect against water loss and attack by microorganisms. In animals, waxes coat the skin, hair, and feathers, which keep these structures pliable and waterproof.
22. The molecules of both types of lipids have hydrophilic and hydrophobic ends. Thus, both types of lipids can interact with polar and nonpolar phases simultaneously. The cleansing action of soaps relies on this physical property.

Section Review 27.5

Part A Completion

1. nucleotide
2. deoxyribonucleic acid
3. ribonucleic acid
4. proteins
5. nitrogen base
6. adenine, guanine, thymine, or cytosine
7. adenine, guanine, thymine, or cytosine
8. adenine, guanine, thymine, or cytosine
9. adenine, guanine, thymine, or cytosine
10. uracil
11. double helix
12. hydrogen bonds
13. thymine
14. cytosine

Part B True-False

15. AT
16. AT
17. ST
18. AT

Part C Matching

19. b
20. e
21. c
22. a
23. d

Part D Questions and Problems

24. Mutations are random changes in the sequence of nucleotides in a DNA molecule. Mutations may arise from additions, deletions, or substitutions of one or more of the nucleotides. When a mutation occurs within a gene, it may stop production of the specified protein or cause production of a protein with an altered amiono acid sequence. Sometimes the change is beneficial; more often, the ability of the protein to function is seriously impaired. For example, a mutation in the peptide chain of hemoglobin reduces its ability to transport oxygen. People with this mutation have a molecular disease called sickle cell anemia, which is named for the distorted shape of the defective red blood cells.

Section Review 27.6

Part A Completion

1. adenosine triphosphate
2. adenosine diphosphate
3. oxidation
4. 30.5 kJ
5. nonspontaneous
6. catabolic or anabolic
7. catabolic or anabolic
8. metabolism
9. catabolism
10. anabolism

Part B True-False

11. AT
12. AT
13. NT
14. AT
15. NT
16. AT

Part C Matching

17. d
18. b
19. c
20. a

Part D Questions and Problems

21. The free energy of ATP hydrolysis is used to drive many nonspontaneous biological reactions. ATP hydrolysis provides the extra energy needed to shift the equilibrium of a nonspontaneous reaction in favor of the products. ATP captures energy from catabolism reactions to drive anabolism reactions.

Interpreting Graphics 27

Part A

1. cytoplasm
2. cell membrane
3. cell wall
4. nucleus
5. cytoplasm
6. cell membrane

Part B

1. The cell in panel **a** represents a prokaryotic cell. It lacks a nucleus and organelles, which are present in eukaryotic cells such as the one depicted in panel **b**. Prokaryotic cells are the cells of bacteria. The cells of all other organisms are eukaryotic.
2. Figure 1a: 0.0001 to 0.001 mm, 0.1 to 1.0 μm, 100 to 1000 nm.

   Figure 1b: 0.001 to 0.01 mm, 1.0 to 10.0 μm, 1000 to 10,000 nm.
3. All of the organelle types labeled in Figure 1b are found in a typical plant cell. Plant cells are eukaryotic.
4. Plant cells contain chloroplasts, structures that enable plants to produce carbohydrates through photosynthesis. Plant cells have cell walls.
5. ATP is produced in the mitochondrion and transported out to the cytoplasm, where it is used to fuel nonspontaneous processes.
6. Mitochondria produce energy needed for cellular activities. Muscle cells are highly active cells, which require many mitochondria to meet their energy demands. Skin cells are less active. They contain significantly fewer mitochondria.
7. Carbohydrates are found in the cytoplasm and are attached to the extracellular surfaces of membrane-bound proteins. They comprise the cell walls, which provide structure and rigidity to plant cells. Because proteins catalyze metabolic reactions, they are found throughout the cell. Proteins embedded in cell membranes help to transport molecules and ions across this barrier. Lipids are found mainly in cell and organelle membranes where they form a barrier to the free flow of ions and molecules into and out of the membrane-enclosed

compartments. DNA, a molecule that stores the information needed to make proteins, is found primarily in the nucleus of eukaryotic cells and in the cytoplasm of prokaryotic cells. RNA, a molecule that participates in the transfer of information between DNA and protein, is found in the cytoplasm of all cells.

Vocabulary Review 27

1. c
2. f
3. b
4. g
5. k
6. h
7. e
8. j
9. i
10. d
11. a

Quiz for Chapter 27

1. NT
2. AT
3. NT
4. AT
5. ST
6. d
7. b
8. b
9. d

Chapter 27 Test A

A. Matching

1. e
2. b
3. g
4. i
5. c
6. f
7. a
8. d
9. h
10. j

B. Multiple Choice

11. d
12. b
13. b
14. d
15. b
16. d
17. a
18. c
19. c
20. b
21. d
22. d
23. c
24. a
25. c

C. True-False

26. AT
27. AT
28. NT
29. ST
30. ST
31. AT
32. NT
33. NT
34. AT
35. AT

D. Questions and Problems

36. Trp-Arg-Ala-Leu-Asn-end

37. **a.** $ATP + H_2O \rightarrow ADP + P_i$

b. $K_{eq} = \frac{[ADP][P_i]}{[ATP]} > 1$

c. spontaneous

38. Phosphorus is essential for the synthesis of phospholipids, nucleic acids, and energy-rich molecules such as ATP. Phosphorus is found in the bloodstream as HPO_4^{2-} and $H_2PO_4^-$, which together form an important buffer. Nitrogen is required for the synthesis of amino acids and nitrogen-containing bases of nucleic acids.

39. Test the aqueous solubility of the substance. Many carbohydrates are soluble in water, whereas lipids are not.

40. Eukaryotic cells contain a nucleus and other membrane-enclosed structures called organelles. Prokaryotic cells do not contain a nucleus or organelles. Eukaryotic cells are typically much larger than prokaryotic cells.

41. **a.** A membrane protein that acts as a channel must have contacts inside and outside the cell membrane. To span the entire bilayer, membrane proteins must have dimensions similar to the observed thickness of the lipid bilayer. The length along the transmembrane axis of the protein must be approximately 5 to 10 nm.

b. Because the lipid bilayer is composed of two sheets of phospholipid molecules arranged tail to tail, each phospholipid molecule must be approximately 2.5 to 5 nm long from head to tail.

E. Essay

42. Nucleic acids are polymers found primarily in cell nuclei. They are composed of nucleotides that contain a phosphate group, a five-carbon sugar, and a nitrogen-containing base. There are two types: DNA and RNA. DNA stores the information needed to make proteins. DNA governs the reproduction and growth of cells. RNA has a key role in the transmission of the information stored in DNA.

Chapter 27 Test B

A. Matching

1. c
2. d
3. g
4. i
5. b
6. a
7. f
8. e
9. h
10. j

B. Multiple Choice

11. c	16. d	21. d
12. d	17. d	22. b
13. b	18. c	23. c
14. a	19. c	24. c
15. d	20. b	25. d

C. True-False

26. NT	30. ST	33. AT
27. AT	31. AT	34. AT
28. AT	32. AT	35. NT
29. ST		

D. Questions and Problems

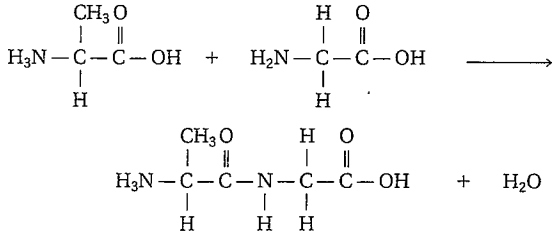
36. More than one answer is possible due to the redundancy of the genetic code. One possibility: 5′ACAGTTGGTACT3′

37. An enzyme catalyzes the conversion of a substrate to product. Doubling and tripling the number of enzyme molecules in the reaction mixture is equivalent to doubling and tripling the number of active sites to which substrate can bind. Thus, when all other conditions are kept the same, the rate at which product is formed will increase with the number of enzyme molecules present in the reaction system.

38. Test the aqueous solubility of the substance. Most proteins are soluble in water, whereas lipids are not.

39. $$2000 \cancel{\text{kJ}} \times \frac{1 \text{ mol ATP}}{30.5 \cancel{\text{kJ}}} \times \frac{507.2 \cancel{\text{g}} \text{ ATP}}{1 \text{ mol ATP}} \times \frac{1 \text{ kg}}{10^3 \cancel{\text{g}}}$$
$$= 33.3 \text{ kg ATP}$$

40. Two dipeptides are possible. One possibility:



41. The extent to which the physical properties of a cell membrane are altered by a substance may depend on the solubility of the substance in the lipid bilayer. Beacuase the interior of the lipid bilayer is a hydrophobic environment, nonpolar substances have the greatest chance of becoming incorporated into this protion of the cell membrane.

E. Essay

42. Enzymes are proteins that, like act as biological catalysts. They reduce the time required for a chemical reaction to reach equilibrium, but do not change the normal position of the equilibrium. Enzymes are not changed by the reactions they promote. The molecules on which an enzyme acts are called substrates. In an enzyme-catalyzed reaction the substrate binds to the active site on the enzyme form an enzyme-substrate complex.. Next, bond-breaking and bond-making occur at the active site to produce the products of the reaction. Finally, the products dissociate from the enzyme leaving the enzyme free to bind new substrate and begin a second reaction cycle.

Section Review 28.1

Part A Completion

1. radioactive	9. electrons
2. radioisotopes	10. aluminum foil
3. nuclei	11. Gamma
4. stable	12. visible light
5. radiation	13. mass
6. beta	14. Lead
7. Alpha	15. concrete
8. helium	16. stop

Part B True-False

17. ST	19. AT	21. AT
18. NT	20. NT	

Part C Matching

22. b	24. c	26. d
23. a	25. e	

Part D Questions and Problems

27. a. $^{218}_{84}\text{Po} \rightarrow {}^{4}_{2}\text{He} + {}^{214}_{82}\text{Pb}$

b. $^{210}_{82}\text{Pb} \rightarrow {}^{210}_{83}\text{Bi} + {}^{0}_{-1}e$

Section Review 28.2

Part A Completion

1. band of stability
2. beta
3. positron
4. rate
5. half-life
6. radioactive
7. millions
8. transmutation
9. high-energy
10. atomic numbers
11. synthesized

Part B True-False

12. NT
13. NT
14. AT
15. ST
16. ST

Part C Matching

17. c
18. e
19. b
20. a
21. d

Part D Questions and Problems

22. $\frac{60\text{ hr}}{15\text{ hr}} = 4$ half-lives; After 4 half-lives

    $1/2 \times 1/2 \times 1/2 \times 1/2 = 1/16$ of the original mass will remain. $1/16 \times 18.0\text{ g} = 1.13\text{ g}$

23. $2.0\text{ g} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 0.25\text{ g}$ or 3 half-lives

    42 days ÷ 3 = 14 days

Section Review 28.3

Part A Completion

1. fission
2. neutrons
3. radioisotopes
4. energy
5. moderation
6. absorption
7. fusion
8. heavier
9. energy
10. hydrogen
11. helium

Part B True-False

12. ST
13. NT
14. NT
15. NT

Part C Matching

16. a
17. c
18. e
19. b
20. d

Part D Questions and Problems

21. **a.** 3 **b.** 4

22. **a.** slow fast-moving neutrons so they can be absorbed by the fuel atoms

    b. decrease the number of slow-moving neutrons and slow the chain reaction

Section Review 28.4

Part A Completion

1. ionizing
2. electrons
3. senses
4. Geiger
5. gas
6. beta
7. scintillation
8. all
9. iodine-131
10. phosphorus-32

Part B True-False

11. AT
12. NT
13. ST
14. AT

Part C Matching

15. b
16. e
17. c
18. a
19. d

Part D Questions and Problems

20. c
21. Neutron activation analysis is used to detect trace amounts of elements in samples. Radioisotopes are used to study chemical reactions and molecular structures. Radioisotopes are used to diagnose and treat diseases such as cancer.

Practice Problems 28

Section 28.1

1. The atomic number increases by one; the mass number remains the same.
2. The atomic number decreases by two; the mass number decreases by four.
3. **a.** 28 protons and 36 neutrons

   b. 53 protons and 83 neutrons

   c. 79 protons and 116 neutrons
4. **a.** $^{14}_{7}\text{N}$ **c.** $^{0}_{-1}e$

   b. $^{237}_{93}\text{Np}$

Section 28.2

1. **a.** $^{208}_{87}\text{Fr} \rightarrow {}^{4}_{2}\text{He} + {}^{204}_{85}\text{At}$

   b. $^{7}_{4}\text{Be} + {}^{0}_{-1}e \rightarrow {}^{7}_{3}\text{Li}$

   c. $^{37}_{18}\text{Ar} \rightarrow {}^{37}_{19}\text{K} + {}^{0}_{-1}e$

   d. $^{17}_{9}\text{F} \rightarrow {}^{17}_{8}\text{O} + {}^{0}_{+1}e$

2. **a.** $^{3}_{1}H$ **d.** $^{144}_{58}Ce$
   b. $^{92}_{36}Kr$ **e.** $^{239}_{94}Pu$
   c. $^{30}_{15}P$
3. It takes five half-lives, or 820 s.
   8.0 g→ 4.0 g→ 2.0 g→ 1.0 g→ 0.50 g→ 0.25 g
4. 16 g → 8 g → 4 g → 2.0 g → 1.0 g
   Four half-lives = 4 × 17 days = 68 days
5. $\frac{51 \text{ min}}{5.1 \text{ min}}$ = 10 half-lives. The mass would decrease by a factor of more than 1000.
   $\left(\frac{1}{2}\right)^{10} = \frac{1}{1024}$
6. The mass decreases by a factor of 1/8, or three half-lives. The half-life is 5.49/3 = 183 s

Section 28.3

1. **a.** 2 ([1 + 235] − [90 + 144] = 2)
   b. 3 ([1 + 235] − [87 + 146] = 3)
   c. 4 ([1 + 235] − [72 + 160] = 4)
2. 2.0×10^{7} kcal ÷ 8.0 kcal/g = 2.5×10^{6} g
3. $^{4}_{2}He$

Section 28.4

1. Radioisotopes replace non-radioactive isotopes in the structure of a compound without changing its chemical properties. Tracing the pathways of radioactive isotopes allows scientists to study reaction mechanisms and reaction rates.
2. Teletherapy is the use of gamma radiation to destroy cancerous tissue.

Interpreting Graphics 28

1. 8
2. 6; $^{238}_{92}U \rightarrow {}^{206}_{82}Pb + 8\,{}^{4}_{2}He + 6\,{}^{0}_{-1}e$
3. 8 days = 2 half-lives; $20 \times \frac{1}{2} \times \frac{1}{2} = 5.0$ g
4. 20 minutes = 1 half-life; 1.0 mol = $6.0 \times 10^{23} \times \frac{1}{2} = 3.0 \times 10^{23}$ atoms
5. lead-210; The half-life of polonium-214 is insignificant compared to the half-life of bismuth-214.
6. Three half-lives = 15 days; 16 g → 8 g → 4 g → 2.0 g.
7. For heavier isotopes, such as lead-206, the stability ratio is about 1.5 neutrons to 1 proton. 124 n ÷ 82 p = 1.5
8. Uranium-238 has the longest half-life (4.5×10^{9} yr); polonium-210 has the shortest half-life (1.6×10^{-4} s).

Vocabulary Review 28

1. b	5. i	9. k
2. l	6. d	10. f
3. g	7. e	11. h
4. a	8. c	12. j

Quiz for Chapter 28

1. d	5. a	8. b
2. b	6. d	9. a
3. c	7. c	10. a
4. b		

Chapter 28 Test A

A. Matching

1. a	5. j	8. f
2. i	6. e	9. h
3. g	7. d	10. b
4. c		

B. Multiple Choice

11. b	17. b	22. a
12. c	18. d	23. b
13. b	19. b	24. a
14. b	20. c	25. d
15. a	21. a	26. b
16. c		

C. Problems

27. **a.** $^{42}_{19}K \rightarrow {}^{0}_{-1}e + {}^{42}_{20}Ca$
    b. $^{235}_{92}U \rightarrow {}^{4}_{2}He + {}^{231}_{90}Th$
28. If one-eighth of the sample remains, the isotope decayed through 3 half-lives.
    Three half-lives is 252 days, so one half-life period = 84 days.
    The half-life of scandium-42 is 84 days.
29. 40 days = 5 half-lives.
    $\frac{1}{32}$ of the original sample remains
    = 0.13 gram remaining.

D. Essay

30. The energy released from the sun is the result of a nuclear fusion, or thermonuclear reaction. Fusion occurs when two light nuclei combine to produce a nucleus of heavier mass. In solar fusion, hdrogen nuclei (protons) are fused to make helium nuclei. The reaction requires two beta particles.

$4\,{}^{1}_{1}\mathrm{H} + 2\,{}^{0}_{-1}e \rightarrow {}^{4}_{2}\mathrm{He}$ + energy

Chapter 28 Test B

A. Matching

1. j	**5.** e	**8.** h
2. i	**6.** g	**9.** b
3. c	**7.** a	**10.** f
4. d		

B. Multiple Choice

11. a	**16.** d	**21.** d
12. d	**17.** b	**22.** d
13. c	**18.** a	**23.** d
14. b	**19.** a	**24.** a
15. a	**20.** c	**25.** d

C. Problems

26. **a.** ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$

b. ${}^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}e$

c. ${}^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}e$

27. 27.0 h/6.75 h = 4.00 half-lives

Thus, $12.0\ \mathrm{g} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 0.750\ \mathrm{g}$

28. $\frac{0.125\ \cancel{\mathrm{g}}}{4.00\ \cancel{\mathrm{g}}} = \frac{1}{32}$ of the sample remains

Since $\frac{1}{32}$ represents $\left(\frac{1}{2}\right)^5$, or 5 half-lives,

$\frac{71.5\ \text{years}}{5\ \text{half-lives}} = 14.3\ \text{years/half-life}.$

D. Essay

29. **a.** Chemical reactions occur in an effort to attain stable electron configurations. Nuclear reactions occur in an effort to obtain stable nuclear configurations.

b. Nuclear reactions release far more energy than typical exothermic chemical reactions.

c. Unlike chemical reactions, nuclear reactions are unaffected by changes in temperature, pressure, or the presence of a catalyst.