1. The common feature found in all unsaturated hydrocarbons is
   A) one or more carbon-carbon double bonds.
   B) one or more carbon-carbon triple bonds.
   C) one or more carbon-carbon multiple bonds.
   D) one or more rings of carbon atoms.

2. A cycloalkene having only one carbon-carbon double bond will have the general formula
   A) C_nH_{2n+2}
   B) C_nH_{2n}
   C) C_nH_{2n-2}
   D) C_nH_{2n-4}

3. The correct IUPAC name for \[ \text{CH}_3\text{CHCHCHCH}_3 \]
   is
   A) 2-methylpentene.
   B) 2-methyl-3,4-pentene.
   C) 2-methyl-3-pentene.
   D) 4-methyl-2-pentene.

4. The correct IUPAC name for \[ \text{CH}_2\text{CH=CHCH}_2 \]
   is
   A) 1,4-butene.
   B) 1,3-butadiene.
   C) 1,3-dibutene.
   D) 1,4-dibutene.

5. The correct IUPAC name for \[ \text{CH}_3\text{-} \]
   is
   A) 1-methyl-2-cyclopropene
   B) 2-methyl-1-cyclopropene
   C) 1-methylcyclopropene
   D) 3-methylcyclopropene
6. The bond angles associated with a carbon-carbon double bond in an alkene are
   A) 180º.
   B) 120º.
   C) 109º.
   D) 90º.

7. *Cis-trans* isomerism is possible for which of the following alkenes?
   A) CH₂=CH–CH₂–CH₂–CH₃
   B) CH₃–CH=CH–CH₂–CH₃
   C) CH₃–CH=CH₂
   D) CH₂=CH–CH₂–CH₃

8. Which of the following reactants can be used to convert an alkene to an alkane?
   A) H₂
   B) Cl₂
   C) HCl
   D) H₂O

9. Markovnikov's rule is needed to predict the product in the reaction between HCl and
   A) CH₂=CH₂.
   B) CH₃–CH=CH–CH₃.
   C) CH₂=CH–CH₃.
   D) CH₃–CH₃.

10. Which of the following addition polymers contains only carbon and hydrogen?
    A) polystyrene
    B) PVC
    C) teflon
    D) saran

11. Which of the following addition polymers is produced from a *diene* monomer?
    A) polyethylene
    B) polypropylene
    C) PVC
    D) natural rubber
12. Which of the following addition polymers is produced from monomers that are dienes?  
   A) polyethylene  
   B) polypropylene  
   C) polyvinylchloride  
   D) natural rubber

13. Which of the following alkynes goes by the common name of acetylene?  
   A) ethyne  
   B) propyne  
   C) 1-butyne  
   D) 2-butyne

14. The bonding in benzene differs from that of other unsaturated hydrocarbons in that each carbon atom participates in  
   A) one single bond and three double bonds.  
   B) three single bonds and three double bonds.  
   C) one single bond and one “delocalized” bond.  
   D) three single bonds and one “delocalized” bond.

15. How many total atoms are present in a molecule of benzene?  
   A) eight  
   B) ten  
   C) twelve  
   D) fourteen

16. Another name for p-dibutylbenzene is  
   A) 1,2-dibutylbenzene  
   B) 1,3-dibutylbenzene  
   C) 1,4-dibutylbenzene  
   D) 1,5-dibutylbenzene

17. Which of the following benzene derivatives is a monosubstituted benzene?  
   A) 3-ethyltoluene  
   B) 1,3-dicyclopentylbenzene  
   C) 3-phenyl-1-butene  
   D) 1,3-diphenylbenzene
18. The IUPAC name for the hydrocarbon

\[
\text{CH}_3\text{--CH}_2\text{--CH}_2\text{--CH}--\text{CH}_2\text{--CH}_3
\]

A) 3- benzylhexane.  
B) 4- benzylhexane.  
C) 3- phenylhexane.  
D) 4- phenylhexane.

19. Which of the following statements about the chemical properties of benzene is correct?  
A) It readily undergoes both substitution reactions and addition reactions.  
B) It readily undergoes substitution reactions but not addition reactions.  
C) It readily undergoes addition reactions but not substitution reactions.  
D) It does not undergo either substitution reactions or addition reactions.

20. With the catalyst AlCl₃ present, which reactant is needed to convert benzene to ethylbenzene?  
A) \text{CH}_3\text{--CH}_3  
B) \text{CH}_3\text{--CH}_2\text{--Cl}  
C) \text{CH}_3\text{--CH}_2\text{--OH}  
D) \text{CH}_2=\text{CH}_2

21. The classification unsaturated hydrocarbon includes within it  
A) both alkenes and cycloalkenes.  
B) both alkenes and alkynes.  
C) both cycloalkenes and aromatic hydrocarbons.  
D) more than one correct response  
E) no correct response

22. Which of the following molecular formulas could not represent an alkene with one double bond?  
A) \text{C}_6\text{H}_{12}  
B) \text{C}_6\text{H}_6  
C) \text{C}_2\text{H}_{10}  
D) more than one correct response  
E) no correct response
23. Which of the following alkenes is paired with an *incorrect* IUPAC name?
   A) CH₂=CH–CH₂–CH₃; 1-butene
   B) CH₃–CH=CH–CH₃; 2-butene
   C) CH₃–CH₂–CH=CH₂; 3-butene
   D) more than one correct response
   E) no correct response

24. Which of the following is a *correct* IUPAC name for a substituted cycloalkene?
   A) 1-methyl-2-cyclopentene
   B) 2-methyl-1-cyclopentene
   C) 2-methylcyclopentene
   D) more than one correct response
   E) no correct response

25. Which of the following is *not* a constitutional isomer of 1-pentene?
   A) 2-pentene
   B) 2-methyl-2-butene
   C) cyclopentane
   D) more than one correct response
   E) no correct response

26. The “building block” for terpene compounds is the
   A) 4-carbon pheromone unit.
   B) 5-carbon isoprene unit.
   C) 5-carbon pheromone unit.
   D) more than one correct response
   E) no correct response

27. Which of the following is an example of an alkenyl group?
   A) ethenyl group
   B) phenyl group
   C) methylene group
   D) more than one correct response
   E) no correct response

28. Which of the following compounds contains three carbon atoms?
   A) allyl bromide
   B) vinyl chloride
   C) acetylene
   D) more than one correct response
   E) no correct response
29. For which of the following halogenated hydrocarbons is cis-trans isomerism possible?
   A) 1,1-dichloroethene
   B) 1,2-dichloroethene
   C) 1,2-dichloroethyne
   D) more than one correct response
   E) no correct response

30. Markovnikov's rule is needed to predict the organic product in which of the following reactions?
   A) 2-butene + HCl
   B) 1-butene + H₂ (Ni catalyst)
   C) cyclobutene + H₂O (H₂SO₄ catalyst)
   D) more than one correct response
   E) no correct response

31. Which of the following addition polymers contain only two elements?
   A) polyethylene
   B) teflon
   C) PVC
   D) more than one correct response
   E) no correct response

32. Which of the following is an incorrect IUPAC name for a disubstituted benzene?
   A) 2,3-dichlorobenzene
   B) 1-bromo-4-chlorobenzene
   C) 1-bromo-3-methylbenzene
   D) more than one correct response
   E) no correct response

33. For which of the following types of substituted benzenes is the specified number of constitutional isomers correct?
   A) dichlorobenzenes; 3 isomers
   B) trichlorobenzenes; 4 isomers
   C) tetrachlorobenzenes; 4 isomers
   D) more than one correct response
   E) no correct response
34. Which of the following reactions involving benzene produces a disubstituted benzene as the organic product?
   A) alkylation
   B) bromination
   C) chlorination
   D) more than one correct response
   E) no correct response

35. Which of the following reactions involving benzene require the presence of an AlCl₃ catalyst?
   A) alkylation
   B) bromination
   C) chlorination
   D) more than one correct response
   E) no correct response

Use the following to answer questions 36-45:

In each of the following multiple-choice questions, characterize EACH of the three given statements as being TRUE or FALSE and then indicate the collective true-false status of the statements using the choices
   a) All three statements are true.
   b) Two of the three statements are true.
   c) Only one of the statements is true.
   d) None of the statements is true.

36. Statements:
   (1) Unsaturated hydrocarbons have physical properties similar to those of saturated hydrocarbons.
   (2) The catalyst in the alkylation of benzene is sulfuric acid.
   (3) PVC and Saran Wrap are both addition polymers in which the element chlorine is present.
   A) All three statements are true.
   B) Two of the three statements are true.
   C) Only one of the statements is true.
   D) None of the statements is true.
37. Statements:
(1) An allyl group contains three carbon atoms.
(2) Alkenes with one double bond have two fewer hydrogen atoms than their alkane counterparts.
(3) Both toluene and o-xylene are monosubstituted benzene derivatives.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

38. Statements:
(1) Alkenes with two to four carbon atoms are gases at room temperature and pressure.
(2) Aromatic hydrocarbons do not readily undergo addition reactions.
(3) HDPE, LDPE, and Teflon are all ethene-based addition polymers.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

39. Statements:
(1) Terpenes are alkenes which contain five double bonds.
(2) A vinyl group is formed when a hydrogen atom is removed from propylene.
(3) Commonly used catalysts for the hydrogenation of an alkene are the metals nickel and platinum.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

40. Statements:
(1) o-xylene is a benzene derivative with two methyl substituents.
(2) A number is not needed to specify double bond position in the IUPAC names of ethene and propene.
(3) Hydrohalogenation is a symmetrical addition reaction.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.
41. Statements:
   (1) Ethene and ethane molecules have the same geometrical shape.
   (2) Two double bonds are present in the compound allyl chloride.
   (3) Cis-trans isomerism is possible in both 1-butene and 2-butene.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

42. Statements:
   (1) The molecule 1,3-butadiene contains eight hydrogen atoms.
   (2) Two carbon rings that share a pair of carbon atoms are said to be fused.
   (3) The prefix para- is used to indicate 1,3-disubstitution on a benzene ring.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

43. Statements:
   (1) Four double bonds are present in 1,6-heptadiyne.
   (2) Markovnikov's rule is needed to predict the major product formed in the reaction between water and 2-butene.
   (3) The compound benzene contains both localized and delocalized bonds.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.

44. Statements:
   (1) The aluminum chloride catalyzed reaction between benzene and ethyl chloride produces chlorobenzene.
   (2) The compound 2-methyl-1,3-cyclopentadiene has the molecular formula C₆H₈.
   (3) The biochemical activity of pheromones is highly dependent on whether the carbon-carbon double bonds present are in cis- or trans-configurations.
A) All three statements are true.
B) Two of the three statements are true.
C) Only one of the statements is true.
D) None of the statements is true.
45. Statements:
   (1) Ethene is both a plant hormone and a high-volume industrial chemical.
   (2) Carotenoids, compounds which give odor to flowers and plants, have a system of *conjugated* double bonds as a structural feature.
   (3) The process of vision in the human eye involves changes in which carbon-carbon double bonds are converted to carbon-carbon triple bonds.
   A) All three statements are true.
   B) Two of the three statements are true.
   C) Only one of the statements is true.
   D) None of the statements is true.

Use the following to answer questions 46-50:

For each of the hydrocarbons, select from the response list the correct molecular formula. Responses may be used more than once or need not be used at all.

   a) C₇H₈
   b) C₇H₁₀
   c) C₇H₁₂
   d) C₇H₁₄

46. 2,3-Dimethyl-2-pentene

47. 1,3-Heptadiene

48. 3-Heptyne

49. 2-Methylcyclohexene

50. Toluene

Use the following to answer questions 51-55:

For each pair of compounds, select a correct characterization from the response list. Responses may be used more than once or need not be used at all.

   a) are constitutional isomers
   b) have the same number of carbon atoms but are not constitutional isomers
   c) both exist as *cis-trans* isomers
   d) one but not the other exists in *cis-trans* forms
51. 2-Pentene 2-Butene

52. 1-Butyne 1,3-Butadiene

53. Cyclohexene Benzene

54. 3-Methylcyclobutene 3,4-Dimethylcyclobutene

55. o-Diethylbenzene 1,3-Diethylbenzene

Use the following to answer questions 56-60:

For each of the reactions, select a correct product characterization from the response list. Responses may be used more than once or need not be used at all.

a) An alkane is formed.
b) An alkene is formed.
c) An aromatic hydrocarbon is formed.
d) Markovnikov's rule is needed to predict the major organic product.

56. \( \text{CH}_2\text{CH} = \text{CH}_3 + \text{H}_2, \text{Ni} \rightarrow \)

57. \( \text{CH}_2\text{CH} = \text{CH}_3 + \text{HCl} \rightarrow \)

58. \( \text{CH}_2\text{CH} = \text{CH}_3 + \text{H}_2\text{O, H}_2\text{SO}_4 \rightarrow \)

59. \( \text{CH} = \text{CH} + 2\text{H}_2, \text{Ni} \rightarrow \)

60. \( \text{CH}_2\text{CH} = \text{CH} = \text{CH}_2 + \text{H}_2, \text{Ni} \rightarrow \)
Use the following to answer questions 61-65:

For each reaction situation, select a correct product characterization using the response list. Responses may be used more than once or need not be used at all. Assume that any needed catalysts are present.

a) monochlorinated hydrocarbon
b) dichlorinated hydrocarbon
c) trichlorinated hydrocarbon
d) tetrachlorinated hydrocarbon

61. 1-hexyne + one Cl₂
62. 1,4-hexadiene + two Cl₂
63. Cyclohexene + one Cl₂
64. 1,3-cyclohexadiene + one Cl₂
65. Benzene + two Cl₂

Use the following to answer questions 66-70:

For each of the polymers, select a correct polymer characterization using the response list. Responses may be used more than once or need not be used at all.

a) polymer in which all attachments to the carbon chain are identical
b) polymer in which two different monomers are involved
c) polymer in which the monomer is a substituted diene
d) polymer in which the monomer is a monosubstituted ethene

66. Poly(vinyl chloride)
67. Polyethylene
68. Teflon
69. Saran
70. Natural rubber
### Answer Key

1. C  
2. C  
3. D  
4. B  
5. C  
6. B  
7. B  
8. A  
9. C  
10. A  
11. D  
12. D  
13. A  
14. D  
15. C  
16. C  
17. C  
18. C  
19. B  
20. B  
21. D  
22. B  
23. C  
24. C  
25. E  
26. B  
27. D  
28. A  
29. B  
30. E  
31. D  
32. D  
33. A  
34. E  
35. A  
36. B  
37. B  
38. A  
39. C  
40. B  
41. D  
42. C  
43. C  
44. B
45. C
46. d
47. c
48. c
49. c
50. a
51. c
52. a
53. b
54. d
55. a
56. a
57. d
58. d
59. a
60. b
61. b
62. d
63. b
64. b
65. b
66. d
67. a
68. a
69. b
70. c