

## Topic: Introduction to Reaction Mechanisms

### Section: Multiple Choice Questions

1. Which of the following represents heterolytic bond fission?

- (a)  $\text{R-Cl} \rightarrow \text{R} \cdot + \cdot\text{Cl}$
- (b)  $\text{CH}_3\text{-Cl} \rightarrow \text{CH}_3^+ + \text{Cl}^-$
- (c)  $\text{H}_2 \rightarrow \text{H} \cdot + \text{H} \cdot$
- (d)  $\text{Cl-Cl} \rightarrow \text{Cl} \cdot + \text{Cl} \cdot$

2. In a reaction where a nucleophile attacks an electrophile, the curly arrow showing electron movement originates from:

- (a) The electrophilic center
- (b) The bond being formed
- (c) The electron-rich site of the nucleophile
- (d) The bond being broken

3. Which of the following species typically acts as a nucleophile?

- (a)  $\text{H}^+$
- (b)  $\text{BF}_3$
- (c)  $\text{NH}_3$
- (d)  $\text{AlCl}_3$

4. The +I effect (positive inductive effect) of an alkyl group helps in stabilizing which of the following reactive intermediates?

- (a) Carbanion
- (b) Free radical
- (c) Carbocation
- (d) Both (a) and (b)

5. Which of the following conditions is essential for a molecule to exhibit resonance?

- (a) Presence of only single bonds
- (b) Absence of pi electrons
- (c) Presence of delocalized pi electrons
- (d) All atoms must be sp<sup>3</sup> hybridized

6. What is the correct order of stability for carbocations?

- (a) Methyl > Primary > Secondary > Tertiary
- (b) Tertiary > Secondary > Primary > Methyl
- (c) Secondary > Tertiary > Primary > Methyl
- (d) Primary > Secondary > Tertiary > Methyl

7. An example of a substitution reaction is:

- (a)  $\text{CH}_2=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br}$
- (b)  $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O}$
- (c)  $\text{CH}_3\text{Cl} + \text{NaOH} \rightarrow \text{CH}_3\text{OH} + \text{NaCl}$
- (d)  $\text{CH}_3\text{CHO} + \text{HCN} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CN}$

8. The rate of an S<sub>N</sub>1 reaction primarily depends on:

- (a) The concentration of the nucleophile only
- (b) The concentration of the substrate only
- (c) The concentrations of both the substrate and the nucleophile
- (d) The steric hindrance around the leaving group

9. An S<sub>N</sub>2 reaction proceeds with:

- (a) Retention of configuration

- (b) Racemization
- (c) Inversion of configuration
- (d) Formation of a carbocation intermediate

10. The E1 reaction mechanism typically involves:

- (a) A concerted one-step process
- (b) Formation of a carbocation intermediate in the rate-determining step
- (c) Bimolecular rate-determining step
- (d) Requires an anti-periplanar arrangement for the elimination

11. Electrophilic addition reactions are characteristic of compounds containing:

- (a) Only single bonds (alkanes)
- (b) Carbon-carbon double bonds (alkenes)
- (c) Carbon-carbon triple bonds (alkynes)
- (d) Both (b) and (c)

12. Which type of organic compounds readily undergo nucleophilic addition reactions?

- (a) Alkenes
- (b) Alkyl halides
- (c) Aldehydes and Ketones
- (d) Alcohols

13. In the nitration of benzene, which species acts as the active electrophile?

- (a)  $\text{NO}_2^-$
- (b)  $\text{NO}^+$
- (c)  $\text{HNO}_3$
- (d)  $\text{H}_2\text{SO}_4$

14. A reaction energy diagram showing the products at a lower energy level than the reactants indicates:

- (a) An endothermic reaction
- (b) An exothermic reaction
- (c) A non-spontaneous reaction
- (d) A reaction with a positive change in enthalpy

15. Hyperconjugation involves the delocalization of:

- (a) Sigma electrons into an adjacent empty p-orbital or pi-orbital
- (b) Pi electrons into an adjacent empty p-orbital
- (c) Lone pair electrons into an adjacent pi-orbital
- (d) Sigma electrons into another sigma-orbital

#### Answers

- 1. (b)
- 2. (c)
- 3. (c)
- 4. (c)
- 5. (c)
- 6. (b)
- 7. (c)
- 8. (b)
- 9. (c)
- 10. (b)

11. (d)

12. (c)

13. (b)

14. (b)

15. (a)

## Topic: Bond Fission: Homolytic and Heterolytic

### Section: Multiple Choice Questions

16. Which type of bond fission results in the formation of free radicals?

- (a) Heterolytic fission
- (b) Homolytic fission
- (c) Ionic fission
- (d) Coordinate fission

17. In homolytic fission, how are the bonding electrons distributed between the two fragments?

- (a) Both electrons go to one fragment.
- (b) Both electrons remain as a lone pair.
- (c) Each fragment takes one electron from the shared pair.
- (d) Electrons are completely lost to the solvent.

18. What are the common products of heterolytic fission of a C-X bond, where X is more electronegative than C?

- (a) Carbocation and anion
- (b) Carbanion and cation
- (c) Two free radicals
- (d) Two neutral molecules

19. Which of the following conditions typically favors homolytic bond fission?

- (a) Polar solvents
- (b) High dielectric constant
- (c) Presence of Lewis acids
- (d) High temperature or UV light

20. A full-headed arrow (curly arrow) moving from a bond to an atom represents the movement of:

- (a) A single electron during bond formation.
- (b) A single electron during bond breaking.
- (c) A pair of electrons during bond breaking or formation.
- (d) A proton during an acid-base reaction.

21. The stability of free radicals generally follows which order?

- (a) Primary > Secondary > Tertiary
- (b) Tertiary > Secondary > Primary
- (c) Methyl > Tertiary > Secondary
- (d) Secondary > Methyl > Tertiary

22. Which of the following reagents is most likely to initiate a reaction involving homolytic bond fission?

- (a) H<sub>2</sub>O (water)
- (b) AlCl<sub>3</sub> (aluminum chloride)
- (c) Benzoyl peroxide
- (d) NaOH (sodium hydroxide)

23. When a covalent bond between two atoms of different electronegativities breaks heterolytically, the bonding electron pair typically goes to the:

- (a) Less electronegative atom.
- (b) More electronegative atom.
- (c) Larger atom.
- (d) Smaller atom.

24. Which type of intermediate is NOT formed during heterolytic bond fission?

- (a) Carbocation

(b) Carbanion

(c) Free radical

(d) Hydride ion

25. Consider the bond breaking in H-Cl in the presence of water. Which type of fission is most likely to occur?

(a) Homolytic, forming H. and Cl.

(b) Heterolytic, forming H<sup>+</sup> and Cl<sup>-</sup>

(c) Homolytic, forming H<sup>+</sup> and Cl<sup>-</sup>

(d) Heterolytic, forming H. and Cl.

26. A half-headed arrow (fishhook arrow) in a reaction mechanism indicates the movement of:

(a) Two electrons simultaneously.

(b) A single electron.

(c) A proton.

(d) An entire atom.

27. Which of the following characteristics is generally associated with heterolytic bond fission?

(a) Occurs in nonpolar solvents.

(b) Generates uncharged species.

(c) Often initiated by electrophiles or nucleophiles.

(d) Leads to formation of stable molecules only.

28. The C-C bond in ethane (CH<sub>3</sub>-CH<sub>3</sub>) can undergo homolytic fission under specific conditions. What are the products formed?

(a) CH<sub>3</sub><sup>+</sup> and CH<sub>3</sub><sup>-</sup>

(b) CH<sub>3</sub>. and CH<sub>3</sub>.



(c)  $\text{CH}_2=\text{CH}_2$  and  $\text{H}_2$

(d)  $\text{CH}_4$  and  $\text{CH}_2$

29. In the reaction  $\text{CH}_3\text{-Cl} \rightarrow \text{CH}_3^+ + \text{Cl}^-$ , the bond fission is:

(a) Homolytic, forming a carbocation and a chloride radical.

(b) Heterolytic, forming a carbocation and a chloride ion.

(c) Homolytic, forming a methyl radical and a chloride ion.

(d) Heterolytic, forming a carbanion and a chloride cation.

30. Why is heterolytic fission generally favored in polar solvents?

(a) Polar solvents stabilize the charged intermediates through solvation.

(b) Polar solvents provide the energy for bond breaking directly.

(c) Polar solvents increase the bond strength, making fission easier.

(d) Polar solvents act as catalysts by forming intermediate radicals.

## Answers

16. (b)

17. (c)

18. (a)

19. (d)

20. (c)

21. (b)

22. (c)

23. (b)

24. (c)

25. (b)

26. (b)

27. (c)

28. (b)

29. (b)

30. (a)

## Topic: Electron Movement: Curly Arrows

### Section: Multiple Choice Questions

31. Which of the following statements correctly describes the meaning of a curved arrow (curly arrow) in organic reaction mechanisms?

- (a) It shows the movement of a single electron.
- (b) It shows the movement of a pair of electrons.
- (c) It shows the movement of an atom or group.
- (d) It shows the direction of energy flow in the reaction.

32. In a typical nucleophilic attack on an electrophilic carbon, how is the electron movement represented by curly arrows?

- (a) An arrow starts from the electrophilic carbon and points to the nucleophile.
- (b) An arrow starts from the nucleophile and points to the electrophilic carbon.
- (c) Two half-headed arrows start from the nucleophile and point to the electrophilic carbon.
- (d) An arrow starts from a sigma bond and points to the nucleophile.

33. Consider the electrophilic attack of  $H^+$  on an alkene ( $R-CH=CH-R'$ ). Which representation correctly shows the initial electron movement using curly arrows?

- (a) An arrow from the  $H^+$  to the pi bond.
- (b) An arrow from one carbon of the pi bond to the  $H^+$ .
- (c) An arrow from the pi bond to the  $H^+$ .
- (d) An arrow from the pi bond to one carbon, and then another arrow from that carbon to  $H^+$ .

34. When a C-X bond undergoes heterolytic fission where X is more electronegative than C, which curly arrow representation is correct?

- (a) A full-headed arrow starts from the C-X bond and points to C.
- (b) A full-headed arrow starts from the C-X bond and points to X.
- (c) A half-headed arrow starts from the C-X bond and points to C.

(d) A half-headed arrow starts from the C-X bond and points to X.

35. Homolytic cleavage of a C-Br bond, producing free radicals, is best represented by which type of curly arrow?

(a) A full-headed arrow starting from the bond and pointing to Br.

(b) A full-headed arrow starting from the bond and pointing to C.

(c) Two full-headed arrows, one from C to Br and one from Br to C.

(d) Two half-headed arrows, one from the bond to C and one from the bond to Br.

36. In the S<sub>N</sub>2 reaction of methyl iodide with a hydroxide ion, the initial attack involves the hydroxide ion donating a pair of electrons to the methyl carbon. How would this be shown with curly arrows?

(a) An arrow from the lone pair on oxygen to the methyl carbon, and an arrow from the C-I bond to iodine.

(b) An arrow from the lone pair on oxygen to the methyl carbon, and an arrow from the C-I bond to carbon.

(c) An arrow from the methyl carbon to the lone pair on oxygen, and an arrow from the C-I bond to iodine.

(d) An arrow from the lone pair on oxygen to hydrogen on the methyl group, and an arrow from the C-H bond to carbon.

37. Which of the following electron movements correctly depicts the deprotonation of an alcohol (ROH) by a strong base (B<sup>-</sup>), forming an alkoxide (RO<sup>-</sup>)?

(a) An arrow from the B<sup>-</sup> to the O-H bond, and an arrow from the O-H bond to O.

(b) An arrow from the B<sup>-</sup> to the H atom, and an arrow from the O-H bond to O.

(c) An arrow from the O-H bond to B<sup>-</sup>, and an arrow from O to H.

(d) An arrow from O to H, and an arrow from B<sup>-</sup> to O.

38. When an alkene reacts with Br<sub>2</sub>, the first step involves the pi electrons of the alkene attacking a bromine atom. Which curly arrow representation is correct for this initial attack?

(a) An arrow from one carbon of the pi bond to one Br atom.

(b) An arrow from the pi bond to one Br atom, and an arrow from the Br-Br bond to the other Br atom.

(c) An arrow from the Br<sub>2</sub> molecule to the pi bond.

(d) Two half-headed arrows from the pi bond to one Br atom.

39. In the nucleophilic addition of cyanide to a carbonyl group (C=O), how are the electrons typically shown to move?

(a) An arrow from the cyanide carbon to the carbonyl carbon, and an arrow from the C=O pi bond to the carbonyl carbon.

(b) An arrow from the cyanide carbon to the carbonyl carbon, and an arrow from the C=O pi bond to the carbonyl oxygen.

(c) An arrow from the carbonyl oxygen to the cyanide carbon, and an arrow from the C=O pi bond to the carbonyl carbon.

(d) An arrow from the carbonyl carbon to the cyanide carbon, and an arrow from the C=O pi bond to the carbonyl oxygen.

40. Which set of curly arrows correctly shows the delocalization of charge in a carboxylate anion (R-COO<sup>-</sup>)?

(a) An arrow from a lone pair on the negatively charged oxygen to form a C=O pi bond, and an arrow from the existing C=O pi bond to the other oxygen.

(b) An arrow from the C=O pi bond to the negatively charged oxygen, and an arrow from a lone pair on the neutral oxygen to form a C=O pi bond.

(c) An arrow from the C=O pi bond to the carbon, and an arrow from a lone pair on the negatively charged oxygen to form a C=O pi bond.

(d) An arrow from the carbon atom to the negatively charged oxygen, and an arrow from the C=O pi bond to the other oxygen.

41. Which sequence of electron movements (represented by curly arrows) best describes the first step in the acid-catalyzed keto-enol tautomerism, where the carbonyl oxygen is protonated?

(a) An arrow from the pi bond of C=O to H<sup>+</sup>, followed by an arrow from a lone pair on oxygen to form a bond with H<sup>+</sup>.

(b) An arrow from a lone pair on the carbonyl oxygen to H<sup>+</sup>, followed by an arrow from the C=O pi bond to H<sup>+</sup>.

(c) An arrow from the pi bond of C=O to H<sup>+</sup>.

(d) An arrow from the lone pair on the carbonyl oxygen to H<sup>+</sup>.

42. Which of the following curly arrow usages is generally considered incorrect or represents an unstable/unlikely process?

- (a) An arrow from a lone pair on a nucleophile attacking an electrophilic carbon.
- (b) An arrow from a pi bond attacking an electrophile.
- (c) An arrow from a sigma bond attacking a nucleophile.
- (d) An arrow from a lone pair forming a pi bond in resonance.

43. Consider the reaction of HBr with propene. If the curly arrow shows the pi bond of propene attacking  $H^+$ , and then the H-Br bond breaks with electrons moving to Br, what intermediate is primarily formed?

- (a) Primary carbocation.
- (b) Secondary carbocation.
- (c) Primary carbanion.
- (d) Secondary carbanion.

44. When a carbon atom bears a full negative charge and acts as a nucleophile, its electron movement in forming a new bond is typically shown by:

- (a) A full-headed arrow starting from the carbon atom and pointing to the electrophile.
- (b) A half-headed arrow starting from the carbon atom and pointing to the electrophile.
- (c) A full-headed arrow starting from the electrophile and pointing to the carbon atom.
- (d) An arrow starting from a bond adjacent to the carbon atom.

45. In an E2 elimination reaction, the concerted movement of electrons involves the base attacking a beta-hydrogen, the C-H bond breaking and forming a new pi bond, and the leaving group departing. How many full-headed curly arrows are typically used to represent this single step?

- (a) One
- (b) Two
- (c) Three
- (d) Four

## Answers

31. (b)

32. (b)

33. (c)

34. (b)

35. (d)

36. (a)

37. (b)

38. (b)

39. (b)

40. (a)

41. (d)

42. (c)

43. (b)

44. (a)

45. (c)

## Topic: Reagents: Nucleophiles and Electrophiles

46. Which of the following species acts exclusively as an electrophile?

- (a)  $\text{H}_2\text{O}$
- (b)  $\text{NH}_3$
- (c)  $\text{BF}_3$
- (d)  $\text{CH}_3\text{OH}$

47. Which of the following is generally considered a poor nucleophile?

- (a)  $\text{OH}^-$
- (b)  $\text{CN}^-$
- (c)  $\text{H}_2\text{O}$
- (d)  $\text{CH}_3\text{S}^-$

48. Identify the species that possesses both a nucleophilic and an electrophilic center.

- (a) Carbocation
- (b) Carbanion
- (c) Carbonyl group ( $\text{C}=\text{O}$ )
- (d) Free radical

49. Among the following, which option correctly ranks the nucleophilicity in protic solvents from strongest to weakest?

- (a)  $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$
- (b)  $\text{F}^- > \text{Cl}^- > \text{Br}^- > \text{I}^-$
- (c)  $\text{Cl}^- > \text{Br}^- > \text{I}^- > \text{F}^-$
- (d)  $\text{Br}^- > \text{I}^- > \text{Cl}^- > \text{F}^-$

50. Electrophiles are generally defined as:



- (a) Electron rich species that donate electron pairs.
- (b) Electron deficient species that accept electron pairs.
- (c) Species that always carry a positive charge.
- (d) Species that always carry a negative charge.

51. Which of the following statements about nucleophiles is incorrect?

- (a) They are Lewis bases.
- (b) They are attracted to electron-deficient centers.
- (c) They always carry a negative charge.
- (d) They can be neutral molecules with lone pairs of electrons.

52. In the reaction of  $\text{CH}_3\text{-CH=CH}_2$  with  $\text{HBr}$ , the initial attacking species is:

- (a)  $\text{Br}^-$
- (b)  $\text{H}^+$
- (c)  $\text{CH}_3\text{CH}^+\text{CH}_2^-$
- (d)  $\text{HBr}$  itself

53. Which of the following species would act as the strongest nucleophile?

- (a)  $\text{H}_2\text{O}$
- (b)  $\text{OH}^-$
- (c)  $\text{CH}_3\text{COOH}$
- (d)  $\text{CH}_3\text{OH}$

54. Which factor generally decreases the electrophilicity of a carbocation?

- (a) Presence of electron-donating groups attached to the carbocationic carbon.
- (b) Presence of electron-withdrawing groups attached to the carbocationic carbon.

(c) Higher positive charge density on the carbocationic carbon.

(d) Increased stability of the carbocation.

55. Consider the following species:

I.  $\text{NH}_3$

II.  $\text{H}_2\text{O}$

III.  $\text{BF}_3$

IV.  $\text{CH}_3^-$

Which of these can act as a nucleophile?

(a) I and II only

(b) I, II, and IV only

(c) I, II, III, and IV

(d) III only

56. Which statement is true regarding the electrophilic nature of a carbon atom in a carbonyl group ( $\text{C}=\text{O}$ )?

(a) It is electron-rich due to the electronegativity of oxygen.

(b) It is susceptible to attack by nucleophiles.

(c) Its reactivity is decreased by electron-withdrawing groups.

(d) It acts as a Lewis acid and donates electrons.

57. Which of the following is a characteristic of an electrophile?

(a) It has a high electron density.

(b) It seeks out electron-rich centers.

(c) It donates a pair of electrons.

(d) It is always negatively charged.

58. Which of the following molecules can act as both a nucleophile and an electrophile, depending on the reaction conditions?

- (a) Ethene ( $\text{CH}_2=\text{CH}_2$ )
- (b) Methane ( $\text{CH}_4$ )
- (c) Water ( $\text{H}_2\text{O}$ )
- (d) Boron trifluoride ( $\text{BF}_3$ )

59. Arrange the following carbocations in increasing order of their electrophilic strength:

- (i)  $\text{CH}_3^+$
  - (ii)  $(\text{CH}_3)_2\text{CH}^+$
  - (iii)  $(\text{CH}_3)_3\text{C}^+$
  - (iv)  $\text{CH}_3\text{CH}_2^+$
- (a) (iii) < (ii) < (iv) < (i)
  - (b) (i) < (iv) < (ii) < (iii)
  - (c) (iii) < (ii) < (i) < (iv)
  - (d) (i) < (ii) < (iv) < (iii)

60. A species with an unpaired electron is typically involved in which type of reaction intermediate?

- (a) Carbocation
- (b) Carbanion
- (c) Free radical
- (d) Nucleophile

Answers

46. (c)

47. (c)

48. (c)

49. (a)

50. (b)

51. (c)

52. (b)

53. (b)

54. (a)

55. (b)

56. (b)

57. (b)

58. (c)

59. (a)

60. (c)

## Topic: Electronic Displacement Effects

### Section: Multiple Choice Questions

61. Which of the following effects involves the permanent displacement of sigma electrons along a carbon chain?

- (a) Resonance effect
- (b) Inductive effect
- (c) Hyperconjugation
- (d) Electromeric effect

62. The increasing order of acidity for the following compounds is:

- I. Chloroacetic acid
- II. Acetic acid
- III. Bromoacetic acid
- IV. Fluoroacetic acid

- (a)  $\text{II} < \text{III} < \text{I} < \text{IV}$
- (b)  $\text{IV} < \text{I} < \text{III} < \text{II}$
- (c)  $\text{II} < \text{I} < \text{III} < \text{IV}$
- (d)  $\text{IV} < \text{III} < \text{I} < \text{II}$

63. Which of the following carbocations is the most stable?

- (a) Primary carbocation
- (b) Secondary carbocation
- (c) Tertiary carbocation
- (d) Methyl carbocation

64. Hyperconjugation involves the delocalization of:

- (a) pi electrons
- (b) lone pair electrons
- (c) sigma electrons of C-H bond adjacent to a pi system or a carbocation
- (d) d-orbital electrons

65. Which of the following groups exhibits a +M (positive mesomeric) effect?

- (a) -NO<sub>2</sub>
- (b) -COOH
- (c) -OH
- (d) -CN

66. Arrange the following carbanions in increasing order of stability:

I. CH<sub>3</sub>-

II. C<sub>2</sub>H<sub>5</sub>-

III. (CH<sub>3</sub>)<sub>2</sub>CH-

IV. (CH<sub>3</sub>)<sub>3</sub>C-

- (a) IV < III < II < I
- (b) I < II < III < IV
- (c) II < I < IV < III
- (d) III < IV < I < II

67. Which of the following statements about the inductive effect is incorrect?

- (a) It is a permanent effect.
- (b) It involves the complete transfer of electrons.
- (c) It diminishes rapidly with increasing distance.

(d) It can be electron-donating (+I) or electron-withdrawing (-I).

68. Consider the following compounds: Phenol, p-nitrophenol, o-nitrophenol, m-nitrophenol. The strongest acid among these is:

- (a) Phenol
- (b) p-nitrophenol
- (c) o-nitrophenol
- (d) m-nitrophenol

69. In which of the following compounds does resonance NOT play a significant role in stabilizing the molecule?

- (a) Benzene
- (b) But-1-ene
- (c) Carbonate ion ( $\text{CO}_3^{2-}$ )
- (d) Acetate ion ( $\text{CH}_3\text{COO}^-$ )

70. The stability of free radicals follows the order:

- (a) Methyl < Primary < Secondary < Tertiary
- (b) Tertiary < Secondary < Primary < Methyl
- (c) Primary < Methyl < Secondary < Tertiary
- (d) Secondary < Primary < Tertiary < Methyl

71. Which of the following is an example of a temporary electronic effect?

- (a) Inductive effect
- (b) Resonance effect
- (c) Hyperconjugation
- (d) Electromeric effect

72. The order of +I effect of alkyl groups is:

(a)  $\text{CH}_3^- < \text{CH}_3\text{CH}_2^- < (\text{CH}_3)_2\text{CH}^- < (\text{CH}_3)_3\text{C}^-$

(b)  $(\text{CH}_3)_3\text{C}^- < (\text{CH}_3)_2\text{CH}^- < \text{CH}_3\text{CH}_2^- < \text{CH}_3^-$

(c)  $\text{CH}_3\text{CH}_2^- < \text{CH}_3^- < (\text{CH}_3)_2\text{CH}^- < (\text{CH}_3)_3\text{C}^-$

(d)  $\text{CH}_3^- < (\text{CH}_3)_2\text{CH}^- < \text{CH}_3\text{CH}_2^- < (\text{CH}_3)_3\text{C}^-$

73. How does the  $-\text{NO}_2$  group affect the acidity of benzoic acid when present at the para position?

(a) Decreases acidity due to +M effect.

(b) Increases acidity due to -M effect.

(c) Decreases acidity due to +I effect.

(d) Increases acidity due to hyperconjugation.

74. The delocalization of pi electrons through p-orbitals of adjacent atoms is known as:

(a) Inductive effect

(b) Electromeric effect

(c) Resonance effect

(d) Hyperconjugation

75. Which effect is responsible for the ortho and para directing nature of  $-\text{OH}$  group in electrophilic aromatic substitution?

(a) -I effect

(b) +I effect

(c) +M effect

(d) -M effect

Answers

61. (b)



62. (a)

63. (c)

64. (c)

65. (c)

66. (a)

67. (b)

68. (b)

69. (b)

70. (a)

71. (d)

72. (a)

73. (b)

74. (c)

75. (c)

## Topic: Inductive Effect (+I, -I)

### Section: Multiple Choice Questions

76. Which of the following groups exhibits a positive inductive effect (+I) when attached to a carbon chain?

- (a)  $\text{-NO}_2$
- (b)  $\text{-COOH}$
- (c)  $\text{-CH}_3$
- (d)  $\text{-CN}$

77. The correct increasing order of acidity for the following carboxylic acids is:

- (I) Acetic acid ( $\text{CH}_3\text{COOH}$ )
- (II) Trichloroacetic acid ( $\text{CCl}_3\text{COOH}$ )
- (III) Chloroacetic acid ( $\text{ClCH}_2\text{COOH}$ )
- (IV) Dichloroacetic acid ( $\text{Cl}_2\text{CHCOOH}$ )

- (a)  $\text{I} < \text{III} < \text{IV} < \text{II}$
- (b)  $\text{II} < \text{IV} < \text{III} < \text{I}$
- (c)  $\text{I} < \text{II} < \text{III} < \text{IV}$
- (d)  $\text{III} < \text{I} < \text{IV} < \text{II}$

78. Which of the following amines will be the most basic in an aqueous solution?

- (a)  $\text{CH}_3\text{NH}_2$
- (b)  $(\text{CH}_3)_2\text{NH}$
- (c)  $(\text{CH}_3)_3\text{N}$
- (d)  $\text{NH}_3$

79. Among the following carbocations, which one is the most stable?

- (a)  $\text{CH}_3\text{-CH}_2^+$
- (b)  $(\text{CH}_3)_2\text{CH}^+$
- (c)  $(\text{CH}_3)_3\text{C}^+$
- (d)  $\text{CH}_3^+$

80. Which of the following carbanions is the most stable?

- (a)  $\text{CH}_3\text{-CH}_2^-$
- (b)  $(\text{CH}_3)_2\text{CH}^-$
- (c)  $(\text{CH}_3)_3\text{C}^-$
- (d)  $\text{CH}_3^-$

81. The inductive effect operates primarily through which of the following?

- (a) pi-bonds
- (b) sigma-bonds
- (c) lone pair electrons
- (d) empty p-orbitals

82. Which of the following statements about the inductive effect is incorrect?

- (a) It is a permanent effect.
- (b) It involves the complete transfer of electrons.
- (c) It decreases rapidly with increasing distance.
- (d) It influences the acidity and basicity of compounds.

83. Arrange the following halogen groups in increasing order of their negative inductive effect (-I):

-Cl, -F, -Br, -I

- (a)  $-\text{I} < -\text{Br} < -\text{Cl} < -\text{F}$

(b)  $-F < -Cl < -Br < -I$

(c)  $-Br < -I < -Cl < -F$

(d)  $-Cl < -F < -Br < -I$

84. Which of the following alkyl groups has the strongest positive inductive effect (+I)?

(a) Methyl ( $-CH_3$ )

(b) Ethyl ( $-CH_2CH_3$ )

(c) Isopropyl ( $-(CH_3)_2CH$ )

(d) tert-Butyl ( $-(CH_3)_3C$ )

85. Consider the acidity of the following compounds:

(I) Ethanol ( $CH_3CH_2OH$ )

(II) 2,2,2-Trichloroethanol ( $CCl_3CH_2OH$ )

(III) Methanol ( $CH_3OH$ )

The correct order of increasing acidity is:

(a)  $III < I < II$

(b)  $I < III < II$

(c)  $II < I < III$

(d)  $I < II < III$

86. Inductive effect can best explain the stability order of which type of reactive intermediate?

(a) Benzyl carbocation

(b) Allyl carbocation

(c) Simple alkyl carbocations (e.g., primary, secondary, tertiary)

(d) Phenoxide ion

87. What is the primary reason for the decrease in inductive effect with increasing distance along a carbon chain?

- (a) Steric hindrance from bulky groups.
- (b) The electronegativity difference becomes less significant.
- (c) The partial charge created diminishes rapidly through successive sigma bonds.
- (d) Resonance effects become dominant over longer distances.

88. In the context of inductive effect, a group that donates electrons towards the carbon chain is generally designated as what type of group?

- (a) Electron Withdrawing Group (EWG)
- (b) Electron Donating Group (EDG)
- (c) -I group
- (d) Neutral group

89. Which of the following carboxylic acids will have the highest pK<sub>a</sub> value?

- (a) HCOOH (Formic acid)
- (b) ClCH<sub>2</sub>COOH (Chloroacetic acid)
- (c) CH<sub>3</sub>COOH (Acetic acid)
- (d) FCH<sub>2</sub>COOH (Fluoroacetic acid)

90. Which of the following species has the greatest electron deficiency, primarily due to the nature of the carbon atom it carries, as influenced by inductive effects?

- (a) CH<sub>3</sub>CH<sub>2</sub><sup>+</sup> (Ethyl carbocation)
- (b) CH<sub>3</sub>CH<sub>2</sub><sup>-</sup> (Ethyl carbanion)
- (c) CH<sub>3</sub>CH<sub>2</sub>· (Ethyl radical)
- (d) CH<sub>3</sub>COOH (Acetic acid)

Answers

76. (c)

77. (a)

78. (b)

79. (c)

80. (d)

81. (b)

82. (b)

83. (a)

84. (d)

85. (b)

86. (c)

87. (c)

88. (b)

89. (c)

90. (a)

## Topic: Resonance Effect (Mesomeric Effect, +M, -M)

### Section: Multiple Choice Questions

91. Which of the following groups exhibits a strong +M (Mesomeric) effect when attached to a benzene ring?

- a) -NO<sub>2</sub>
- b) -CN
- c) -OH
- d) -CHO

92. Identify the group that primarily exhibits a -M (Mesomeric) effect when directly bonded to a pi-system.

- a) -NH<sub>2</sub>
- b) -OCH<sub>3</sub>
- c) -Cl
- d) -COOH

93. Which statement accurately describes the resonance effect?

- a) It is a permanent displacement of sigma electrons along a chain.
- b) It involves the delocalization of pi electrons or lone pairs of electrons.
- c) Its strength decreases rapidly with increasing distance from the substituent.
- d) It causes polarization of the sigma bond due to electronegativity difference.

94. Consider the following statements about the Resonance (Mesomeric) effect and Inductive effect:

I. Resonance effect involves the delocalization of pi electrons, while Inductive effect involves the displacement of sigma electrons.

II. Resonance effect is generally stronger than the Inductive effect in determining chemical properties.

III. Resonance effect is distance-dependent, while Inductive effect is distance-independent.

Which of the statements are correct?

- a) I and II only
- b) II and III only
- c) I and III only
- d) All I, II, and III

95. A substituent showing a positive mesomeric effect (+M) when attached to a benzene ring will:

- a) Increase electron density at meta positions.
- b) Decrease electron density at ortho and para positions.
- c) Increase electron density at ortho and para positions.
- d) Decrease electron density equally at all positions.

96. Which of the following carbocations is most stabilized by the resonance effect?

- a)  $\text{CH}_3\text{-CH}_2^+$
- b)  $(\text{CH}_3)_3\text{C}^+$
- c)  $\text{CH}_2=\text{CH-CH}_2^+$
- d)  $\text{C}_6\text{H}_5\text{-CH}_2^+$

97. The presence of which group at the para position will significantly increase the acidity of benzoic acid?

- a)  $-\text{CH}_3$
- b)  $-\text{OCH}_3$
- c)  $-\text{OH}$
- d)  $-\text{NO}_2$

98. Which of the following species is stabilized by a negative mesomeric effect (-M)?

- a) Phenoxide ion



b) Aniline

c) Benzaldehyde

d) Carbonyl group in an alpha-beta unsaturated ketone

99. Arrange the following carbanions in increasing order of stability based on the resonance effect:

(I)  $\text{CH}_3\text{-CH}_2\text{-}$

(II)  $\text{CH}_2=\text{CH-CH}_2\text{-}$

(III)  $\text{C}_6\text{H}_5\text{-CH}_2\text{-}$

a) (I) < (II) < (III)

b) (III) < (II) < (I)

c) (II) < (III) < (I)

d) (I) < (III) < (II)

100. Identify the incorrect statement regarding the application of the mesomeric effect.

a) +M groups activate the benzene ring towards electrophilic substitution.

b) -M groups deactivate the benzene ring towards electrophilic substitution.

c) The anilinium ion is more basic than aniline due to the +M effect.

d) The resonance effect plays a crucial role in the acidity of carboxylic acids.

101. Which of the following groups, when attached to a benzene ring, would exert the strongest +M effect?

a)  $\text{-NH}_2$

b)  $\text{-OH}$

c)  $\text{-OCH}_3$

d)  $\text{-F}$

102. What is the primary role of the resonance effect in the ortho-para directing nature of  $\text{-NH}_2$  group in electrophilic aromatic substitution?

- a) It deactivates the meta position more than ortho/para positions.
- b) It stabilizes the carbocation intermediate formed at ortho/para positions.
- c) It withdraws electrons from the benzene ring, making it less reactive.
- d) It causes steric hindrance at the meta position.

103. Which of the following compounds will exhibit the strongest -M effect from its substituent?

- a) Nitrobenzene
- b) Benzoic acid
- c) Benzaldehyde
- d) Acetophenone

104. How does the resonance effect influence the basicity of aniline compared to cyclohexylamine?

- a) Aniline is more basic because the lone pair on nitrogen is delocalized through resonance, making it less available.
- b) Aniline is less basic because the lone pair on nitrogen is delocalized through resonance, making it less available.
- c) Aniline is more basic because the lone pair on nitrogen is more localized in cyclohexylamine.
- d) The resonance effect has no significant impact on the basicity difference between them.

105. In which of the following molecules can resonance structures be drawn?

- a) Methane
- b) Ethane
- c) Ethene
- d) Benzene

Answers

91. (c)

92. (d)

93. (b)

94. (a)

95. (c)

96. (d)

97. (d)

98. (d)

99. (a)

100. (c)

101. (a)

102. (b)

103. (a)

104. (b)

105. (d)

## Topic: Hyperconjugation

106. Which type of electron delocalization is characteristic of hyperconjugation?

- (a) pi-electrons into empty p-orbital
- (b) sigma-electrons into empty p-orbital
- (c) lone pair electrons into pi-system
- (d) d-orbital electrons into pi-system

107. Hyperconjugation is also known by which of the following names?

- (a) Mesomeric effect
- (b) Inductive effect
- (c) Baker-Nathan effect
- (d) Electromeric effect

108. What is the primary requirement for a molecule to exhibit hyperconjugation?

- (a) Presence of a benzene ring
- (b) Presence of an alpha-hydrogen atom
- (c) Presence of a hydroxyl group
- (d) Presence of a halogen atom

109. Which of the following carbocations is most stable due to hyperconjugation?

- (a) Methyl carbocation
- (b) Ethyl carbocation
- (c) Isopropyl carbocation
- (d) tert-Butyl carbocation

110. Consider the stability of the following alkenes: I. Ethene, II. Propene, III. 2-Methylpropene. Which is the correct order of stability from least to most stable?

(a)  $I < II < III$

(b)  $III < II < I$

(c)  $I < III < II$

(d)  $II < I < III$

111. How many alpha-hydrogens are present in 2,3-dimethyl-2-butene for hyperconjugation?

(a) 3

(b) 6

(c) 9

(d) 12

112. The stability of free radicals follows a similar trend to carbocations. Which of the following free radicals is the least stable?

(a) tert-Butyl radical

(b) Isopropyl radical

(c) Ethyl radical

(d) Methyl radical

113. In hyperconjugation, the delocalization of electrons occurs from a C-H sigma bond to which type of orbital in a carbocation?

(a) Filled p-orbital

(b) Empty p-orbital

(c) s-orbital

(d)  $sp^2$  hybrid orbital

114. Which of the following compounds will not exhibit hyperconjugation?

(a) Toluene

- (b) Propene
- (c) Methane
- (d) Ethylbenzene

115. Hyperconjugation primarily contributes to the stabilization of which of the following reactive intermediates?

- (a) Carbanions
- (b) Electrophiles
- (c) Carbocations
- (d) Nucleophiles

116. Among the following, which alkene is stabilized by the maximum number of hyperconjugative structures?

- (a) 1-Butene
- (b) Propene
- (c) Ethene
- (d) 2-Methyl-2-butene

117. Which of the following statements about hyperconjugation is incorrect?

- (a) It involves sigma-pi conjugation.
- (b) It is also known as "no-bond resonance".
- (c) It stabilizes electron-deficient species.
- (d) It is stronger than the resonance effect.

118. The C-C single bond adjacent to a double bond in a molecule like propene shows partial double bond character due to hyperconjugation. This means the C-C single bond length will be:

- (a) Longer than a normal C-C single bond
- (b) Shorter than a normal C-C single bond
- (c) Identical to a normal C-C single bond

(d) Varies depending on temperature

119. In the context of hyperconjugation, what is an "alpha-carbon"?

(a) The carbon atom directly attached to a halogen.

(b) The carbon atom directly attached to the  $sp^2$  carbon (in alkene) or carbon bearing positive charge (in carbocation) or carbon bearing unpaired electron (in free radical).

(c) The carbon atom with a full positive charge.

(d) The carbon atom forming a triple bond.

120. Which of the following effects is generally considered the weakest among the permanent electronic effects, but still significant for stabilizing intermediates and alkenes?

(a) Resonance effect

(b) Inductive effect

(c) Hyperconjugation

(d) Electromeric effect

## Answers

106. (b)

107. (c)

108. (b)

109. (d)

110. (a)

111. (d)

112. (d)

113. (b)

114. (c)

115. (c)

116. (d)

117. (d)

118. (b)

119. (b)

120. (c)



## Topic: Reactive Intermediates

121. Which of the following is an intermediate formed by heterolytic bond fission?

- (a) Free radical
- (b) Carbocation
- (c) Alkene
- (d) Alkane

122. The most stable carbocation among the following is:

- (a) Methyl carbocation
- (b) Primary carbocation
- (c) Secondary carbocation
- (d) Tertiary carbocation

123. Which of the following factors primarily stabilizes a carbocation?

- (a) Electron-withdrawing groups
- (b) Resonance and hyperconjugation
- (c) Lone pair electrons
- (d) Presence of a negative charge

124. The correct order of stability for carbanions (excluding resonance stabilization) is generally:

- (a) Methyl > Primary > Secondary > Tertiary
- (b) Tertiary > Secondary > Primary > Methyl
- (c) Primary > Secondary > Methyl > Tertiary
- (d) Secondary > Primary > Tertiary > Methyl

125. Which of the following reactive intermediates has an unpaired electron?

- (a) Carbocation
- (b) Carbanion
- (c) Free radical
- (d) Both (a) and (b)

126. The hybridization of the carbon atom in a carbocation is:

- (a) sp
- (b) sp<sup>2</sup>
- (c) sp<sup>3</sup>
- (d) dsp<sup>2</sup>

127. The hybridization of the carbon atom in a simple alkyl carbanion (e.g., CH<sub>3</sub><sup>-</sup>) is typically:

- (a) sp
- (b) sp<sup>2</sup>
- (c) sp<sup>3</sup>
- (d) dsp<sup>2</sup>

128. Which of the following reactive intermediates is planar?

- (a) Methyl carbanion
- (b) Methyl free radical
- (c) Methyl carbocation
- (d) Both (b) and (c)

129. Rearrangements in carbocations occur to form a more stable carbocation. Which type of shift commonly facilitates this?

- (a) Alpha elimination
- (b) 1,2-Hydride shift

(c) Beta elimination

(d) Syn addition

130. Consider the carbocation:  $(\text{CH}_3)_2\text{CH}-\text{CH}_2^+$ . Which of the following would be the most stable rearranged carbocation product?

(a)  $(\text{CH}_3)_2\text{C}^+-\text{CH}_3$

(b)  $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2^+$

(c)  $\text{CH}_3-\text{CH}^+-\text{CH}_2-\text{CH}_3$

(d)  $(\text{CH}_3)_3\text{C}^+$

131. Which of the following reaction mechanisms proceeds via the formation of a carbocation intermediate?

(a)  $\text{S}_\text{N}2$  reaction

(b)  $\text{E}2$  reaction

(c)  $\text{S}_\text{N}1$  reaction

(d) Free radical addition

132. Homolytic fission of a C-X bond typically leads to the formation of:

(a) Carbocation and an anion

(b) Carbanion and a cation

(c) Two free radicals

(d) A neutral molecule

133. Arrange the following carbocations in increasing order of stability:

I.  $\text{CH}_3^+$

II.  $(\text{CH}_3)_2\text{CH}^+$

III.  $\text{CH}_3\text{CH}_2^+$

IV.  $(\text{CH}_3)_3\text{C}^+$

(a)  $I < III < II < IV$

(b)  $IV < II < III < I$

(c)  $I < II < III < IV$

(d)  $III < I < II < IV$

134. Which of the following carbanions is the most stable?

(a)  $\text{CH}_3\text{-CH}_2\text{-}$

(b)  $(\text{CH}_3)_3\text{C-}$

(c)  $\text{CH}_3\text{-}$

(d)  $\text{CH}_2=\text{CH-CH}_2\text{-}$  (Allyl carbanion)

135. Which of the following free radicals is the most stable?

(a) Primary free radical

(b) Secondary free radical

(c) Tertiary free radical

(d) Methyl free radical

## Answers

121. (b)

122. (d)

123. (b)

124. (a)

125. (c)

126. (b)

127. (c)

128. (d)

129. (b)

130. (a)

131. (c)

132. (c)

133. (a)

134. (d)

135. (c)

## Topic: Carbocations (Stability, Rearrangements)

### Section: Multiple Choice Questions

136. Which of the following orders correctly represents the decreasing stability of carbocations?

(a) Tertiary > Secondary > Primary > Methyl

(b) Methyl > Primary > Secondary > Tertiary

(c) Secondary > Tertiary > Primary > Methyl

(d) Primary > Secondary > Tertiary > Methyl

137. The primary factor responsible for the greater stability of a tertiary carbocation compared to a primary carbocation is:

(a) Inductive effect only

(b) Resonance effect only

(c) Hyperconjugation and Inductive effect

(d) Steric hindrance

138. Which of the following carbocations is expected to be the most stable?

(a)  $\text{CH}_3\text{-CH}_2^+$

(b)  $\text{CH}_3\text{-CH}^+\text{-CH}_3$

(c)  $(\text{CH}_3)_3\text{C}^+$

(d)  $\text{C}_6\text{H}_5\text{-CH}_2^+$

139. What is the hybridization of the carbon atom bearing the positive charge in a carbocation?

(a) sp

(b) sp<sup>2</sup>

(c) sp<sup>3</sup>

(d) sp<sup>3</sup>d

140. Carbocations are typically formed by which type of bond fission?

- (a) Homolytic fission
- (b) Heterolytic fission
- (c) Both homolytic and heterolytic fission
- (d) Pericyclic bond fission

141. Which of the following carbocations is the least stable?

- (a) Allyl carbocation
- (b) Vinyl carbocation
- (c) Benzyl carbocation
- (d) Isopropyl carbocation

142. A 1,2-hydride shift involves the migration of a:

- (a) Methyl group from one carbon to an adjacent positively charged carbon.
- (b) Hydrogen atom from one carbon to an adjacent positively charged carbon.
- (c) Hydroxyl group from one carbon to an adjacent positively charged carbon.
- (d) Phenyl group from one carbon to an adjacent positively charged carbon.

143. When 2-bromo-2-methylpropane undergoes  $S_N1$  reaction, the carbocation formed is:

- (a) Primary
- (b) Secondary
- (c) Tertiary
- (d) Vinylic

144. Electron-donating groups attached to the positively charged carbon atom in a carbocation generally:

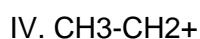
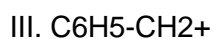
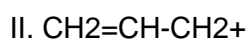
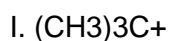
- (a) Decrease its stability

- (b) Increase its stability
- (c) Have no effect on its stability
- (d) First increase then decrease its stability

145. Which of the following statements about carbocation rearrangements is incorrect?

- (a) Rearrangements occur to form a more stable carbocation.
- (b) 1,2-Alkyl shifts are a common type of rearrangement.
- (c) Rearrangements always involve the migration of an atom or group to an adjacent carbon.
- (d) Rearrangements only occur in the presence of strong bases.

146. Consider the following carbocations:



The correct order of decreasing stability is:

- (a)  $\text{I} > \text{II} > \text{III} > \text{IV}$
- (b)  $\text{III} > \text{II} > \text{I} > \text{IV}$
- (c)  $\text{III} > \text{I} > \text{II} > \text{IV}$
- (d)  $\text{I} > \text{III} > \text{II} > \text{IV}$

147. Which of the following carbocations is least likely to undergo a rearrangement?

- (a) 1-Methylpropyl carbocation
- (b) 2-Methyl-1-propyl carbocation
- (c) 2,2-Dimethylpropyl carbocation



(d) tert-Butyl carbocation

148. In the formation of a carbocation, the carbon atom that carries the positive charge has:

- (a) A complete octet of electrons.
- (b) Six valence electrons.
- (c) An unhybridized p-orbital containing two electrons.
- (d) A pair of non-bonding electrons.

149. Which effect contributes significantly to the stability of benzylic carbocations?

- (a) Inductive effect only
- (b) Hyperconjugation only
- (c) Resonance effect
- (d) Steric effect

150. A primary carbocation can often rearrange to a more stable secondary or tertiary carbocation via:

- (a) Elimination reaction
- (b) Nucleophilic attack
- (c) 1,2-Shift of an alkyl group or hydride
- (d) Free radical formation

#### Answers

136. (a)

137. (c)

138. (d)

139. (b)

140. (b)

141. (b)

142. (b)

143. (c)

144. (b)

145. (d)

146. (c)

147. (d)

148. (b)

149. (c)

150. (c)

## Topic: Carbanions (Stability)

### Section: Multiple Choice Questions

151. Which of the following statements is true regarding a carbanion?

- (a) It is an electron-deficient species.
- (b) It possesses a positive charge.
- (c) It has an unshared pair of electrons and a negative charge on carbon.
- (d) It is formed by homolytic bond fission.

152. The geometry of a carbanion is generally:

- (a) Planar
- (b) Linear
- (c) Pyramidal
- (d) Tetrahedral

153. Which of the following carbanions is the most stable?

- (a) Primary carbanion
- (b) Secondary carbanion
- (c) Tertiary carbanion
- (d) Methyl carbanion

154. The stability of carbanions is increased by groups that:

- (a) Donate electrons
- (b) Withdraw electrons
- (c) Undergo hyperconjugation
- (d) Have a positive inductive effect (+I)

155. Arrange the following carbanions in increasing order of stability:

I.  $\text{CH}_3^-$

II.  $\text{CH}_2=\text{CH}-\text{CH}_2^-$

III.  $\text{C}_6\text{H}_5-\text{CH}_2^-$

IV.  $(\text{CH}_3)_3\text{C}^-$

(a)  $\text{IV} < \text{I} < \text{III} < \text{II}$

(b)  $\text{IV} < \text{III} < \text{I} < \text{II}$

(c)  $\text{I} < \text{IV} < \text{III} < \text{II}$

(d)  $\text{II} < \text{III} < \text{I} < \text{IV}$

156. The carbanion formed from 1-propyne ( $\text{CH}_3-\text{C}\equiv\text{CH}$ ) by removal of the terminal proton is more stable than the carbanion formed from propane ( $\text{CH}_3-\text{CH}_2-\text{CH}_3$ ) by removal of a primary proton. This is due to:

(a) Inductive effect

(b) Resonance effect

(c) Hybridization effect

(d) Hyperconjugation

157. Which of the following carbanions is stabilized by aromaticity?

(a) Phenyl carbanion

(b) Benzyl carbanion

(c) Cyclopentadienyl carbanion

(d) Allyl carbanion

158. The relative stability order of methyl carbanion, vinyl carbanion, and ethynyl carbanion is:

(a) Methyl < Vinyl < Ethynyl

(b) Ethynyl < Vinyl < Methyl

(c) Vinyl < Methyl < Ethynyl

(d) Methyl < Ethynyl < Vinyl

159. Which of the following compounds has the most acidic alpha-hydrogen, thus forming the most stable carbanion upon deprotonation?

(a) Acetone

(b) Ethanol

(c) Ethane

(d) Toluene

160. Carbanions are generally:

(a) Electrophiles

(b) Lewis acids

(c) Nucleophiles

(d) Free radicals

161. An electron-withdrawing group like  $\text{-NO}_2$ , when present on the carbon bearing the negative charge, increases carbanion stability primarily due to:

(a) +I effect

(b) Resonance effect and -I effect

(c) Hyperconjugation

(d) Steric hindrance

162. Consider the acidity of the following protons:

I. Acetylene ( $\text{H-C}\equiv\text{CH}$ )

II. Ethylene ( $\text{CH}_2=\text{CH}_2$ )

III. Ethane ( $\text{CH}_3\text{-CH}_3$ )

The order of acidity is  $I > II > III$ . This order is directly related to the stability of their conjugate carbanions, which is primarily due to:

- (a) Increase in s-character of the carbon bearing the negative charge.
- (b) Increase in p-character of the carbon bearing the negative charge.
- (c) Inductive effect of alkyl groups.
- (d) Resonance stabilization.

163. The carbanion  $(CH_3)_3C^-$  is less stable than  $CH_3^-$  due to:

- (a) Resonance effect
- (b) +I effect of methyl groups
- (c) Hyperconjugation
- (d) Electronegativity difference

164. Which of the following factors does NOT contribute to the stabilization of a carbanion?

- (a) Delocalization of the negative charge
- (b) High s-character of the orbital holding the lone pair
- (c) Presence of electron-donating groups
- (d) Presence of electron-withdrawing groups

165. The pyramidal geometry of a carbanion allows for a phenomenon known as:

- (a) Racemization
- (b) Inversion of configuration (umbrella inversion)
- (c) Retention of configuration
- (d) Homolytic cleavage

Answers

151. (c)

152. (c)

153. (d)

154. (b)

155. (a)

156. (c)

157. (c)

158. (a)

159. (a)

160. (c)

161. (b)

162. (a)

163. (b)

164. (c)

165. (b)

## Topic: Free Radicals (Stability)

166. Which type of bond fission leads to the formation of free radicals?

- (a) Heterolytic fission
- (b) Homolytic fission
- (c) Ionic fission
- (d) Both heterolytic and homolytic fission

167. Which of the following is the correct order of stability for alkyl free radicals?

- (a) Tertiary > Secondary > Primary > Methyl
- (b) Methyl > Primary > Secondary > Tertiary
- (c) Primary > Secondary > Tertiary > Methyl
- (d) Secondary > Primary > Methyl > Tertiary

168. The stability of alkyl free radicals increases with the number of alkyl groups attached to the carbon atom bearing the odd electron. This phenomenon is primarily explained by:

- (a) Inductive effect
- (b) Resonance effect
- (c) Hyperconjugation
- (d) Electromeric effect

169. Which of the following free radicals is stabilized by resonance?

- (a) Methyl radical
- (b) Ethyl radical
- (c) Benzyl radical
- (d) Vinyl radical

170. Among the following, the most stable free radical is:



- (a)  $\text{CH}_3$ . (Methyl)
- (b)  $\text{CH}_3\text{CH}_2$ . (Ethyl)
- (c)  $\text{CH}_2=\text{CH}-\text{CH}_2$ . (Allyl)
- (d)  $(\text{CH}_3)_3\text{C}$ . (tert-Butyl)

171. Which of the following free radicals is least stable?

- (a) Primary alkyl radical
- (b) Secondary alkyl radical
- (c) Allyl radical
- (d) Methyl radical

172. The presence of electron-donating groups (e.g., alkyl groups) attached to the carbon bearing the unpaired electron generally \_\_\_\_\_ the stability of free radicals.

- (a) Decreases
- (b) Increases
- (c) Has no effect on
- (d) First decreases then increases

173. Consider the following free radicals:

I.  $(\text{CH}_3)_2\text{CH}$ .

II.  $\text{CH}_3$ .

III.  $\text{C}_6\text{H}_5\text{CH}_2$ .

IV.  $(\text{CH}_3)_3\text{C}$ .

What is the correct order of their decreasing stability?

- (a)  $\text{III} > \text{IV} > \text{I} > \text{II}$
- (b)  $\text{IV} > \text{III} > \text{I} > \text{II}$

(c)  $\text{III} > \text{I} > \text{IV} > \text{II}$

(d)  $\text{IV} > \text{I} > \text{III} > \text{II}$

174. A carbon atom bearing an unpaired electron and bonded to two other carbon atoms is called a:

(a) Primary free radical

(b) Secondary free radical

(c) Tertiary free radical

(d) Methyl free radical

175. Which type of carbon atom is most likely to form a stable free radical?

(a) A carbon atom with no  $\alpha$ -hydrogens.

(b) A carbon atom with an unpaired electron, adjacent to a double bond.

(c) A carbon atom with an unpaired electron, attached to three hydrogen atoms.

(d) A carbon atom with an unpaired electron, attached to an electron-withdrawing group.

176. Identify the most stable free radical among the following:

(a)  $\text{CH}_3\text{-CH}_2\cdot$

(b)  $\text{CH}_2=\text{CH}\cdot$

(c)  $(\text{CH}_3)_2\text{CH}\cdot$

(d)  $(\text{C}_6\text{H}_5)_3\text{C}\cdot$  (Triphenylmethyl radical)

177. Vinyl radical ( $\text{CH}_2=\text{CH}\cdot$ ) is generally considered to be less stable than a primary alkyl radical due to:

(a)  $\text{sp}^2$  hybridized carbon bearing the odd electron.

(b) lack of hyperconjugation.

(c) inductive effect.

(d) resonance effect.

178. The stability of free radicals is NOT significantly influenced by:

- (a) Resonance
- (b) Hyperconjugation
- (c) Steric hindrance around the radical center
- (d) Inductive effect of adjacent alkyl groups

179. The unpaired electron in a free radical is typically found in:

- (a) An empty p-orbital
- (b) A filled s-orbital
- (c) A half-filled atomic orbital
- (d) A fully-filled p-orbital

180. Which of the following groups, when attached to a free radical center, would best stabilize it via resonance?

- (a) -CH<sub>3</sub>
- (b) -OCH<sub>3</sub>
- (c) -CN
- (d) -NO<sub>2</sub>

Answers

166. (b)

167. (a)

168. (c)

169. (c)

170. (c)

171. (d)

172. (b)

173. (a)

174. (b)

175. (b)

176. (d)

177. (a)

178. (c)

179. (c)

180. (b)

## Topic: Types of Organic Reactions

181. Which type of reaction involves the replacement of an atom or group by another atom or group?

- (a) Addition reaction
- (b) Elimination reaction
- (c) Substitution reaction
- (d) Rearrangement reaction

182. The reaction of ethene with HBr is an example of which type of organic reaction?

- (a) Nucleophilic substitution
- (b) Electrophilic addition
- (c) Free radical addition
- (d) Elimination reaction

183. Consider the hydrolysis of tert-butyl bromide. This reaction proceeds predominantly via which mechanism?

- (a) SN2
- (b) E1
- (c) SN1
- (d) E2

184. Dehydration of ethanol in the presence of concentrated H<sub>2</sub>SO<sub>4</sub> at 443 K predominantly yields ethene. This is an example of a/an:

- (a) Addition reaction
- (b) Substitution reaction
- (c) Elimination reaction
- (d) Rearrangement reaction

185. Which of the following carbocations is the most stable?

- (a) Methyl carbocation
- (b) Primary carbocation
- (c) Secondary carbocation
- (d) Tertiary carbocation

186. A species that is electron deficient and accepts an electron pair is known as a/an:

- (a) Nucleophile
- (b) Electrophile
- (c) Free radical
- (d) Carbanion

187. Homolytic fission of a covalent bond leads to the formation of:

- (a) Carbocations
- (b) Carbanions
- (c) Free radicals
- (d) Both (a) and (b)

188. The presence of an alkyl group (like -CH<sub>3</sub>) adjacent to a carbocation enhances its stability primarily due to:

- (a) Inductive effect
- (b) Resonance effect
- (c) Hyperconjugation
- (d) Both (a) and (c)

189. In an S<sub>N</sub>2 reaction, if the reactant is chiral, the product formed will have:

- (a) Retention of configuration
- (b) Inversion of configuration

(c) Racemization

(d) Both retention and inversion

190. Nitration of benzene is an example of:

(a) Nucleophilic substitution

(b) Electrophilic aromatic substitution

(c) Free radical substitution

(d) Electrophilic addition

191. Aldehydes and ketones undergo which type of reaction with reagents like HCN or Grignard reagents?

(a) Electrophilic addition

(b) Nucleophilic addition

(c) Electrophilic substitution

(d) Free radical substitution

192. Which of the following represents an example of tautomerism?

(a) Cis-trans isomerism

(b) Keto-enol isomerism

(c) Position isomerism

(d) Chain isomerism

193. The stability order of free radicals is:

(a) Primary > Secondary > Tertiary

(b) Tertiary > Secondary > Primary

(c) Methyl > Primary > Secondary

(d) Primary > Methyl > Secondary

194. Which of the following is considered a strong nucleophile?

- (a)  $\text{H}_2\text{O}$
- (b)  $\text{CH}_3\text{OH}$
- (c)  $\text{OH}^-$
- (d)  $\text{H}^+$

195. A reaction involving the migration of an atom or group from one position to another within the same molecule is termed a/an:

- (a) Addition reaction
- (b) Elimination reaction
- (c) Substitution reaction
- (d) Rearrangement reaction

#### Answers

181. (c)

182. (b)

183. (c)

184. (c)

185. (d)

186. (b)

187. (c)

188. (d)

189. (b)

190. (b)



191. (b)

192. (b)

193. (b)

194. (c)

195. (d)

## Topic: Substitution Reactions

### Section: Multiple Choice Questions

196. Which of the following reactions is an example of a nucleophilic substitution reaction?

- (a)  $\text{CH}_2=\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br}$
- (b)  $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- (c)  $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow{\text{conc. H}_2\text{SO}_4} \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O}$
- (d)  $\text{CH}_4 + \text{Cl}_2 \xrightarrow{\text{UV light}} \text{CH}_3\text{Cl} + \text{HCl}$

197. The  $\text{S}_\text{N}2$  reaction mechanism primarily involves:

- (a) Formation of a carbocation intermediate.
- (b) A two-step process with a slow and a fast step.
- (c) A concerted process with a transition state.
- (d) Racemization of the chiral center.

198. Which of the following substrates would be most reactive towards an  $\text{S}_\text{N}1$  reaction?

- (a)  $\text{CH}_3\text{Br}$
- (b)  $\text{CH}_3\text{CH}_2\text{Br}$
- (c)  $(\text{CH}_3)_2\text{CHBr}$
- (d)  $(\text{CH}_3)_3\text{CBr}$

199.  $\text{S}_\text{N}1$  reactions at a chiral carbon center typically lead to:

- (a) Complete inversion of configuration.
- (b) Complete retention of configuration.
- (c) Racemization.
- (d) Elimination product only.

200. Polar protic solvents like water or alcohols favor which of the following reactions?

- (a) SN2 reaction
- (b) E2 reaction
- (c) SN1 reaction
- (d) Both SN2 and E2 reactions

201. Which of the following is the best leaving group in a nucleophilic substitution reaction?

- (a) -OH
- (b) -F
- (c) -Cl
- (d) -I

202. The rate of an SN1 reaction depends on the concentration of:

- (a) Only the nucleophile.
- (b) Only the substrate.
- (c) Both the nucleophile and the substrate.
- (d) Neither the nucleophile nor the substrate.

203. The order of reactivity for SN2 reactions with alkyl halides (RX) is:

- (a) 3 degree > 2 degree > 1 degree > CH<sub>3</sub>X
- (b) CH<sub>3</sub>X > 1 degree > 2 degree > 3 degree
- (c) 2 degree > 1 degree > 3 degree > CH<sub>3</sub>X
- (d) 1 degree > 2 degree > CH<sub>3</sub>X > 3 degree

204. Which of the following carbocations is the most stable and therefore most likely to be an intermediate in an SN1 reaction?

- (a) Methyl carbocation

- (b) Primary carbocation
- (c) Secondary carbocation
- (d) Tertiary carbocation

205. Friedel-Crafts alkylation reaction is an example of:

- (a) Nucleophilic addition reaction.
- (b) Electrophilic aromatic substitution reaction.
- (c) Free radical substitution reaction.
- (d) Nucleophilic substitution reaction.

206. Chlorination of methane in the presence of UV light proceeds via which mechanism?

- (a) Electrophilic substitution.
- (b) Nucleophilic substitution.
- (c) Free radical substitution.
- (d) Addition reaction.

207. Which of the following acts as a good nucleophile but a relatively weak base?

- (a)  $\text{HO}^-$
- (b)  $\text{CH}_3\text{O}^-$
- (c)  $\text{H}_2\text{N}^-$
- (d)  $\text{I}^-$

208. If a reaction involves the attack of a nucleophile from the back-side of the leaving group, leading to inversion of configuration, it is characteristic of:

- (a)  $\text{S}_\text{N}1$  reaction
- (b)  $\text{S}_\text{N}2$  reaction
- (c)  $\text{E}1$  reaction

(d) E2 reaction

209. The presence of bulky groups near the reaction center in the substrate will primarily hinder:

(a) SN1 reaction

(b) Electrophilic Addition reaction

(c) SN2 reaction

(d) Free Radical Substitution reaction

210. Which of the following statements is true regarding a carbocation intermediate in an SN1 reaction?

(a) It is sp<sup>3</sup> hybridized and tetrahedral.

(b) It is sp<sup>2</sup> hybridized and planar.

(c) It is a very stable intermediate.

(d) It is formed in the rate-determining step, which is bimolecular.

## Answers

196. (b)

197. (c)

198. (d)

199. (c)

200. (c)

201. (d)

202. (b)

203. (b)

204. (d)

205. (b)

206. (c)

207. (d)

208. (b)

209. (c)

210. (b)

## Topic: Addition Reactions

### Section: Multiple Choice Questions

211. Which of the following best describes an addition reaction?

- (a) A reaction where two or more molecules combine to form a larger molecule with the elimination of a small molecule.
- (b) A reaction where two or more molecules combine to form a single larger molecule without the elimination of any atom.
- (c) A reaction where an atom or group is replaced by another atom or group.
- (d) A reaction involving the breaking of a single bond and formation of a double bond.

212. In the electrophilic addition of HBr to propene, the major product formed follows which rule?

- (a) Saytzeff's rule
- (b) Hofmann's rule
- (c) Markovnikov's rule
- (d) Anti-Markovnikov's rule

213. The intermediate formed during the electrophilic addition of HBr to 2-methylpropene is a:

- (a) Primary carbocation
- (b) Secondary carbocation
- (c) Tertiary carbocation
- (d) Free radical

214. When propene reacts with HBr in the presence of an organic peroxide, the major product obtained is:

- (a) 1-bromopropane
- (b) 2-bromopropane
- (c) 1,2-dibromopropane

(d) Propyl bromide peroxide

215. Which of the following reagents is used for the hydration of alkenes to form alcohols?

(a)  $\text{H}_2\text{O}$  / Pt

(b)  $\text{H}_2\text{SO}_4$  /  $\text{H}_2\text{O}$

(c)  $\text{NaOH}$  /  $\text{H}_2\text{O}$

(d)  $\text{KMnO}_4$  (dilute, cold)

216. The addition of bromine water to an alkene results in the formation of:

(a) Dihaloalkane

(b) Halohydrin

(c) Vicinal diol

(d) Alkane

217. Identify the nucleophile in the addition reaction of  $\text{HCN}$  to an aldehyde.

(a)  $\text{H}^+$

(b) C-N (cyanide ion)

(c) O (from carbonyl oxygen)

(d) The aldehyde itself

218. Which of the following alkenes would react fastest with  $\text{HBr}$  via electrophilic addition?

(a) Ethene

(b) Propene

(c) 2-methylpropene

(d) But-1-ene

219. The anti-addition of  $\text{Br}_2$  to an alkene typically proceeds through the formation of which intermediate?



- (a) Carbocation
- (b) Free radical
- (c) Carbanion
- (d) Bromonium ion

220. The reaction of 2-butene with HBr can lead to the formation of 2-bromobutane. This reaction is an example of:

- (a) Nucleophilic substitution
- (b) Electrophilic addition
- (c) Free radical substitution
- (d) Elimination reaction

221. Catalytic hydrogenation of an alkene (addition of H<sub>2</sub> in presence of Ni, Pd, or Pt) is an example of:

- (a) Electrophilic addition
- (b) Nucleophilic addition
- (c) Free radical addition
- (d) Syn addition

222. Which of the following compounds will undergo nucleophilic addition reactions most readily?

- (a) Ethane
- (b) Ethene
- (c) Propanone
- (d) Benzene

223. What is the product when methyl vinyl ether (CH<sub>2</sub>=CH-O-CH<sub>3</sub>) reacts with HBr?

- (a) 1-bromo-1-methoxyethane
- (b) 2-bromo-1-methoxyethane

(c) 1-bromo-2-methoxyethane

(d) 1,2-dibromo-1-methoxyethane

224. Consider the reaction of an alkene with cold, dilute, alkaline  $\text{KMnO}_4$ . This reaction is known as:

(a) Ozonolysis

(b) Baeyer's test

(c) Markovnikov's addition

(d) Wurtz reaction

225. The stability order of carbocations which influences regioselectivity in electrophilic addition reactions is:

(a) Primary > Secondary > Tertiary

(b) Tertiary > Secondary > Primary

(c) Secondary > Primary > Tertiary

(d) Primary > Tertiary > Secondary

## Answers

211. (b)

212. (c)

213. (c)

214. (a)

215. (b)

216. (b)

217. (b)

218. (c)

219. (d)

220. (b)

221. (d)

222. (c)

223. (a)

224. (b)

225. (b)

## Topic: Elimination Reactions

### Section: Multiple Choice Questions

226. Which of the following statements is INCORRECT regarding the E2 elimination reaction?

- (a) It is a concerted, one-step process.
- (b) It involves a carbocation intermediate.
- (c) The rate depends on the concentration of both substrate and base.
- (d) The leaving group and the hydrogen atom are removed simultaneously.

227. Dehydrohalogenation of 2-bromobutane with alcoholic KOH predominantly yields:

- (a) But-1-ene
- (b) But-2-ene
- (c) 2-ethoxybutane
- (d) Butane

228. Which of the following conditions would favor an E1 reaction over an E2 reaction?

- (a) Strong, bulky base and a primary alkyl halide.
- (b) Strong, unhindered base and a tertiary alkyl halide.
- (c) Weak base/nucleophile and a tertiary alkyl halide in a protic solvent.
- (d) Strong nucleophile and a secondary alkyl halide.

229. The rate of an E1 reaction depends on the concentration of:

- (a) Substrate only
- (b) Base only
- (c) Both substrate and base
- (d) Neither substrate nor base

230. In the dehydrohalogenation of alkyl halides, the Saytzeff product is the one that is:

- (a) Less substituted alkene
- (b) More substituted alkene
- (c) Terminal alkene
- (d) Alkane

231. Identify the major elimination product formed when 2-bromopentane reacts with potassium tert-butoxide (a bulky base) in tert-butanol.

- (a) Pent-1-ene
- (b) Pent-2-ene
- (c) 2-tert-butoxy-pentane
- (d) 2-methylbut-1-ene

232. Which of the following alkyl halides is most likely to undergo an E1 reaction?

- (a)  $\text{CH}_3\text{CH}_2\text{Br}$
- (b)  $\text{CH}_3\text{Br}$
- (c)  $(\text{CH}_3)_3\text{C-Br}$
- (d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$

233. The E2 reaction requires the leaving group and the hydrogen being removed to be in an:

- (a) eclipsed conformation
- (b) gauche conformation
- (c) syn-periplanar conformation
- (d) anti-periplanar conformation

234. Dehydration of alcohols to alkenes proceeds via which mechanism in the presence of concentrated  $\text{H}_2\text{SO}_4$  and heat?

- (a)  $\text{S}_{\text{N}}1$

(b) SN2

(c) E1

(d) E2

235. Which of the following reagents is typically used for dehydrohalogenation of alkyl halides to form alkenes?

(a) Aqueous NaOH

(b) Alcoholic KOH

(c) AgCN

(d) LiAlH<sub>4</sub>

236. What is the intermediate formed during an E1 elimination reaction?

(a) Carbanion

(b) Carbocation

(c) Free radical

(d) Alkyl radical

237. A tertiary alkyl halide, (CH<sub>3</sub>)<sub>3</sub>C-Br, when heated with ethanol as a solvent and a weak base/nucleophile, is most likely to undergo:

(a) SN2 reaction

(b) E2 reaction

(c) SN1 and E1 reactions concurrently

(d) Free radical substitution

238. Hofmann elimination generally favors the formation of the:

(a) more substituted alkene

(b) less substituted alkene

(c) most stable carbocation

(d) a saturated alkane

239. Which of the following factors INCREASES the rate of an E2 reaction?

(a) Decreasing the concentration of the base.

(b) Using a polar protic solvent.

(c) Increasing the steric hindrance around the beta-hydrogen.

(d) Increasing the strength of the base.

240. When 1-bromopropane reacts with sodium ethoxide (NaOEt) in ethanol, the major elimination product formed is:

(a) Propane

(b) Propyne

(c) Prop-1-ene

(d) 1-ethoxypropane

## Answers

226. (b)

227. (b)

228. (c)

229. (a)

230. (b)

231. (a)

232. (c)

233. (d)

234. (c)

235. (b)

236. (b)

237. (c)

238. (b)

239. (d)

240. (c)



## Topic: Rearrangement Reactions

### Section: Multiple Choice Questions

241. Rearrangement reactions primarily occur to:

- (a) Increase the activation energy of the reaction
- (b) Form a more stable intermediate or product
- (c) Achieve a specific stereochemical outcome
- (d) Facilitate the breaking of strong bonds

242. Which of the following reactive intermediates is most prone to undergo rearrangement?

- (a) Carbanion
- (b) Free radical
- (c) Carbocation
- (d) Neutral molecule

243. The most common type of shift observed during a carbocation rearrangement is a:

- (a) 1,1-shift
- (b) 1,2-shift
- (c) 1,3-shift
- (d) 2,3-shift

244. A carbocation rearrangement typically involves the migration of an atom or group from an adjacent carbon atom to the electron-deficient carbon. This migration is driven by the formation of a:

- (a) Less stable carbocation
- (b) Primary carbocation
- (c) More stable carbocation
- (d) Tertiary carbanion

245. In the reaction of  $(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{OH}$  with  $\text{H}_2\text{SO}_4$ , the expected major product, considering carbocation rearrangement, would be derived from:

- (a) A primary carbocation
- (b) A secondary carbocation
- (c) A tertiary carbocation
- (d) A methyl radical

246. Which of the following groups is LEAST likely to migrate in a 1,2-shift during a carbocation rearrangement?

- (a) Hydrogen atom
- (b) Methyl group
- (c) Phenyl group
- (d) Tertiary butyl group

247. The dehydration of 3,3-dimethylbutan-2-ol with concentrated  $\text{H}_2\text{SO}_4$  involves a carbocation intermediate. Which type of rearrangement is most likely to occur?

- (a) 1,2-Hydride shift
- (b) 1,2-Methyl shift
- (c) Ring expansion
- (d) Ring contraction

248. A distinctive feature of a rearrangement reaction is that it involves:

- (a) The breaking of a pi bond and formation of two sigma bonds
- (b) The breaking of two sigma bonds and formation of a pi bond
- (c) A change in the carbon skeleton of the molecule
- (d) A simple substitution of one group for another without skeletal change

249. During a rearrangement, the migrating group always moves with its:

- (a) Lone pair of electrons
- (b) Half-filled orbital
- (c) Bonding pair of electrons
- (d) Empty orbital

250. Which of the following statements about carbocation rearrangement is INCORRECT?

- (a) It is an intramolecular process.
- (b) It leads to the formation of a more stable carbocation.
- (c) It can involve hydride or alkyl shifts.
- (d) It always involves the formation of a more strained ring.

251. Consider the dehydration of an alcohol. If the initial carbocation formed is secondary and a 1,2-hydride shift can lead to a tertiary carbocation, the shift will:

- (a) Not occur due to high activation energy
- (b) Occur to form the more stable tertiary carbocation
- (c) Result in a less stable product
- (d) Only happen in the presence of a strong base

252. A carbocation with a positive charge on a primary carbon adjacent to a tertiary carbon will most likely undergo a:

- (a) 1,2-Methyl shift
- (b) 1,2-Hydride shift
- (c) Ring expansion
- (d) No rearrangement will occur

253. Ring expansion rearrangement in cyclic systems, such as in the formation of a cyclohexyl carbocation from a cyclopentylmethyl carbocation, typically occurs to:

- (a) Increase ring strain

- (b) Form a smaller ring
- (c) Relieve ring strain and form a more stable carbocation
- (d) Facilitate free radical formation

254. The intermediate carbocation formed during an SN1 reaction can undergo rearrangement if:

- (a) It is already the most stable possible carbocation
- (b) A more stable carbocation can be formed by a 1,2-shift
- (c) The leaving group is a strong base
- (d) The reaction is carried out at low temperature only

255. Which of the following compounds is LEAST likely to undergo carbocation rearrangement upon dehydration?

- (a) 2,2-dimethylpropan-1-ol
- (b) Butan-2-ol
- (c) 2-methylbutan-2-ol
- (d) 3,3-dimethylbutan-2-ol

#### Answers

241. (b)

242. (c)

243. (b)

244. (c)

245. (c)

246. (d)

247. (b)

248. (c)

249. (c)

250. (d)

251. (b)

252. (a)

253. (c)

254. (b)

255. (c)

## Topic: Reaction Energetics: Energy Diagrams

256. Which of the following statements correctly describes an exothermic reaction based on its energy diagram?

- (a) The energy of the products is higher than the energy of the reactants.
- (b) The activation energy for the forward reaction is always higher than for the reverse reaction.
- (c) The enthalpy change ( $\Delta H$ ) for the reaction is negative.
- (d) The transition state is always lower in energy than the reactants.

257. In a typical energy diagram for a one-step organic reaction, what does the difference in energy between the peak of the curve and the energy of the reactants represent?

- (a) Overall enthalpy change ( $\Delta H$ )
- (b) Activation energy ( $E_a$ )
- (c) Energy of the transition state
- (d) Energy of the intermediate

258. Consider an  $S_N1$  reaction mechanism. How many transition states and intermediates would typically be observed in its energy diagram, assuming a two-step process?

- (a) One transition state, one intermediate
- (b) Two transition states, one intermediate
- (c) One transition state, two intermediates
- (d) Two transition states, two intermediates

259. A catalyst is added to a reaction mixture. On an energy diagram, what effect would this have?

- (a) It would lower the energy of the reactants.
- (b) It would lower the energy of the products.
- (c) It would decrease the activation energy of the reaction.
- (d) It would shift the equilibrium towards the products.

260. For a multi-step reaction, the rate-determining step is the step with the:

- (a) Lowest activation energy.
- (b) Highest activation energy.
- (c) Smallest overall enthalpy change.
- (d) Most stable intermediate.

261. An energy diagram shows that the products are significantly more stable than the reactants. This indicates the reaction is likely:

- (a) Endothermic
- (b) Exothermic
- (c) A free radical reaction
- (d) Reversible with a very high activation energy

262. According to Hammond's Postulate, if the transition state of a reaction occurs early (i.e., its energy is close to that of the reactants), the reaction is most likely:

- (a) Highly endothermic
- (b) Highly exothermic
- (c) Reversible and at equilibrium
- (d) Unaffected by temperature changes

263. Which feature on an energy diagram represents a species with a transient existence, where bonds are partially broken and partially formed?

- (a) Reactant
- (b) Product
- (c) Intermediate
- (d) Transition state

264. Consider the acid-catalyzed hydration of an alkene, which involves the formation of a carbocation intermediate. If the carbocation formed is more stable (e.g., tertiary carbocation), what effect would this have on the activation energy for its formation in the first step?

- (a) It would increase the activation energy.
- (b) It would decrease the activation energy.
- (c) It would have no effect on the activation energy.
- (d) It would only affect the overall  $\Delta H$  of the reaction.

265. An energy diagram for a specific reaction shows two distinct peaks and one valley between them. This indicates the reaction proceeds through:

- (a) A concerted mechanism with one transition state.
- (b) A two-step mechanism with one intermediate.
- (c) A three-step mechanism with two intermediates.
- (d) An equilibrium mixture of reactants and products.

266. Which of the following statements is true for an endothermic reaction based on its energy diagram?

- (a) The activation energy for the forward reaction is lower than for the reverse reaction.
- (b) The energy of the products is lower than the energy of the reactants.
- (c) The enthalpy change ( $\Delta H$ ) for the reaction is positive.
- (d) The reaction will always proceed spontaneously.

267. In an  $S_N2$  reaction, which proceeds in a single, concerted step, how many transition states are observed in its energy diagram?

- (a) Zero
- (b) One
- (c) Two
- (d) Depends on the specific reactants

268. A reaction energy diagram illustrates that the first step is slow and the second step is fast. Which of the following is true?

- (a) The first step has a lower activation energy than the second step.



- (b) The second step determines the overall rate of the reaction.
- (c) The transition state of the first step is higher in energy than that of the second step.
- (d) The intermediate formed after the first step is very unstable.

269. Comparing the energy diagrams for SN1 and SN2 reactions, which mechanism generally involves a higher energy carbocation intermediate that can undergo rearrangements?

- (a) SN1
- (b) SN2
- (c) Both SN1 and SN2 equally
- (d) Neither SN1 nor SN2

270. An energy diagram shows that the overall enthalpy change for a reaction is positive. This means:

- (a) Energy is released during the reaction.
- (b) The products are more stable than the reactants.
- (c) The reaction requires energy input to proceed.
- (d) The activation energy must be very low.

## Answers

- 256. (c)
- 257. (b)
- 258. (b)
- 259. (c)
- 260. (b)
- 261. (b)
- 262. (b)

263. (d)

264. (b)

265. (b)

266. (c)

267. (b)

268. (c)

269. (a)

270. (c)