Advanced UV/Visible Spectroscopy MCQs

Application of Ultraviolet/Visible Molecular Absorption Spectrometry

20 Multiple-Choice Questions - 15 non-calculation questions and 5 theoretical wavelength calculations with molecular structures

Circle the single best answer. The answer key and calculation checks are provided at the end of the file.

Part I: Non-Calculation Questions

1. A carbonyl-containing compound exhibits two absorption bands: one at approximately 190 nm with ε ≈ 9,000, and another at approximately 285 nm with ε ≈ 20. Which assignment is most appropriate?

A. The 190 nm band is n→π* while the 285 nm band is π→π*.
B. Both bands arise from n→σ* transitions.
C. The 190 nm band is π→π* while the 285 nm band is n→π*.
D. The 190 nm band is σ→σ* while the 285 nm band is n→σ*.

2. Which sequence correctly arranges the following transitions from the highest energy requirement to the lowest energy requirement?

A. n→π* > π→π* > n→σ* > σ→σ*
B. σ→σ* > n→σ* > π→π* > n→π*
C. π→π* > σ→σ* > n→π* > n→σ*
D. n→σ* > σ→σ* > n→π* > π→π*

3. An absorption band has a molar absorptivity of 650 L mol^{-1} cm^{-1}. According to the chapter, which interpretation is most appropriate?

A. It represents a highly allowed transition with a probability close to unity.
B. It is classified as a low-intensity band and is probably associated with a forbidden transition.
C. It must arise exclusively from a σ→σ* transition.
D. It cannot be detected using UV/Visible spectrometry.

4. Which molecular change most directly produces a bathochromic shift in the absorption of a conjugated chromophore?

A. Increasing the energy difference between the HOMO and LUMO.
B. Interrupting conjugation with an sp^3-hybridized carbon.
C. Lowering the energy of the π* orbital through greater electron delocalization.
D. Removing all alkyl substituents without changing the conjugated system.

5. A saturated compound containing a halogen atom absorbs weakly at approximately 173 nm. Which transition is most likely responsible?

A. n→σ*
B. n→π*
C. π→π*
D. Charge-transfer transition

6. Which statement concerning the orbitals of a carbon-carbon double bond is correct?

A. It consists of two π molecular orbitals formed by head-on overlap.
B. It contains one σ orbital and one π orbital, with the π orbital formed by parallel overlap of atomic p orbitals.
C. It contains only a σ orbital because π orbitals are nonbonding.
D. It contains one bonding orbital and no corresponding antibonding orbitals.

7. Why can normal n-alkanes commonly be used as solvents for measurements in the ordinary UV/Visible region?

A. Their n→π* transitions occur exclusively in the visible region.
B. They contain highly conjugated chromophores with very low absorptivity.
C. Their principal σ→σ* absorption occurs mainly below approximately 185 nm.
D. Their absorption bands are eliminated by hydrogen bonding.

8. Which description best distinguishes an auxochrome from a chromophore?

A. An auxochrome is always a conjugated carbonyl group.
B. An auxochrome generally contains unshared electron pairs and may shift the absorption of an attached chromophore to a longer wavelength.
C. An auxochrome absorbs only through σ→σ* transitions.
D. An auxochrome decreases wavelength by increasing the HOMO-LUMO energy gap.

9. A molecule containing both n and π electrons displays two separate bands in hexane. When the solvent is changed to ethanol, the bands move closer together. Which combination best explains this observation?

A. The π→π* band undergoes a blue shift, while the n→π* band undergoes a red shift.
B. Both bands undergo identical bathochromic shifts.
C. The π→π* band undergoes a red shift, while the n→π* band undergoes a blue shift.
D. The π→π* band becomes forbidden, while the n→π* band disappears.

10. Ethylene exhibits a strong π→π* absorption, whereas acetone exhibits a weak n→π* absorption at a longer wavelength. Which statement is correct?

A. The acetone transition requires more energy and has a greater transition probability.
B. The ethylene transition requires less energy because it occurs at a shorter wavelength.
C. The acetone transition requires less energy but has a much lower transition probability.
D. Both transitions have approximately equal molar absorptivities.

11. For a carbonyl compound possessing nonbonding electrons, which pair most reasonably represents the orbitals involved in its lowest-energy electronic transition?

A. HOMO = σ, LUMO = σ*
B. HOMO = π, LUMO = σ*
C. HOMO = n, LUMO = π*
D. HOMO = π*, LUMO = σ*

12. Which assignment of electromagnetic spectral regions is correct?

A. 250 nm: visible; 500 nm: near infrared; 900 nm: microwave.
B. 250 nm: near ultraviolet; 500 nm: visible; 900 nm: near infrared.
C. 250 nm: far infrared; 500 nm: near ultraviolet; 900 nm: visible.
D. 250 nm: microwave; 500 nm: visible; 900 nm: far ultraviolet.

13. Compared with an isolated or unconjugated diene, a conjugated diene normally absorbs at a longer wavelength primarily because:

A. Conjugation raises the π* energy level and increases antibonding character.
B. Delocalization lowers the π* energy level and decreases the energy required for excitation.
C. Conjugation converts all π electrons into nonbonding electrons.
D. The σ→σ* transition becomes the lowest-energy transition.

14. An absorption spectrum shows a reduction in the height of a band, while the position of λ_{max} remains essentially unchanged. This effect is called:

A. Bathochromism
B. Hypsochromism
C. Hyperchromism
D. Hypochromism

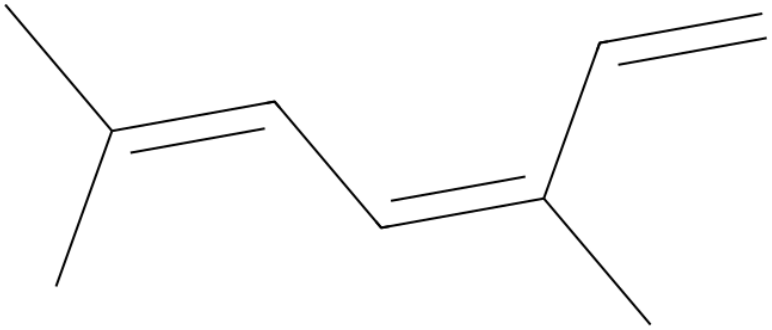
15. According to the practical conditions stated in the chapter, which absorption band is the most suitable for analysis using an ordinary UV/Visible instrument?

A. λ_{max} = 175 nm, ε = 8,000
B. λ_{max} = 205 nm, ε = 700
C. λ_{max} = 192 nm, ε = 1,500
D. λ_{max} = 180 nm, ε = 500

Part II: Theoretical λ_{max} Calculations

Use the Woodward-Fieser rules provided at the end of the chapter.

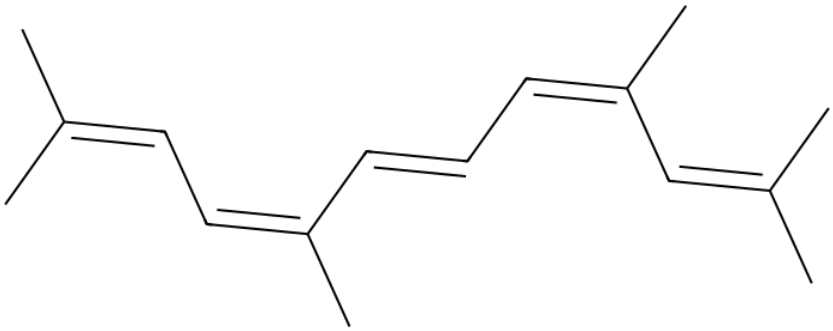
16. Calculate the theoretical λ_{max} for the following acyclic conjugated triene.



Q16: Acyclic conjugated triene

A. 247 nm
B. 257 nm
C. 262 nm
D. 272 nm

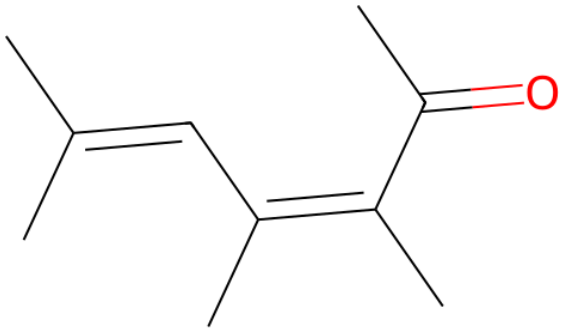
17. The following compound contains five conjugated double bonds. Using the equation given for systems containing more than four conjugated double bonds, calculate its theoretical λ_{max}.



Q17: Conjugated pentaene

A. 332 nm
B. 342 nm
C. 352 nm
D. 362 nm

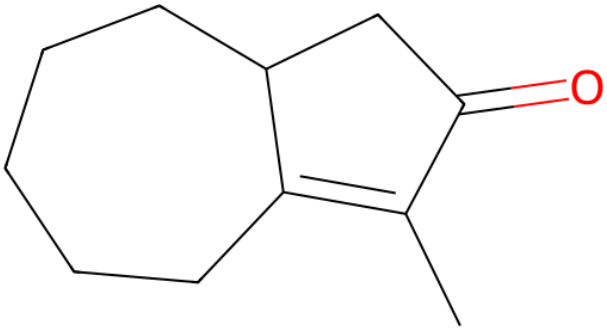
18. Calculate the theoretical λ_{max} of the following extended acyclic enone in water. ~~Include the solvent correction stated in the chapter~~.



Q18: Extended acyclic enone

A. 292 nm
B. 303 nm
C. 311 nm
D. 322 nm

19. Calculate the theoretical λ_{max} for the following five-membered cyclic enone. The conjugated double bond is exocyclic to the fused seven-membered ring.



Q19: Five-membered cyclic enone

A. 226 nm
B. 231 nm
C. 236 nm
D. 241 nm

20. Calculate the theoretical λ_{max} of the following conjugated ester in water. Include the correction for an endocyclic double bond in a seven-membered ring and the solvent correction.

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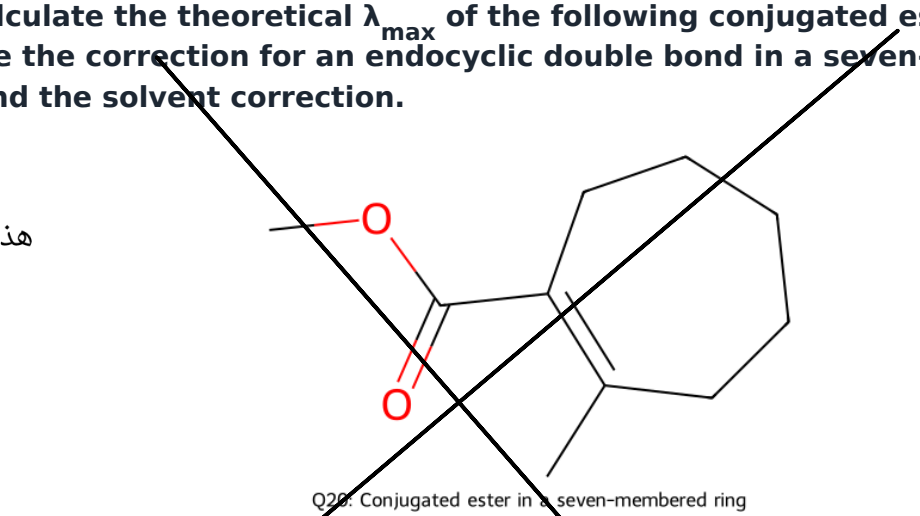

Q20: Conjugated ester in a seven-membered ring

A. 222 nm
B. 234 nm
C. 242 nm
D. 250 nm

Model Answer Key

1	**C**	6	**B**	11	**C**	16	**C**
2	**B**	7	**C**	12	**B**	17	**B**
3	**B**	8	**B**	13	**B**	18	[redacted] B
4	**C**	9	**C**	14	**D**	19	**D**
5	**A**	10	**C**	15	**C**	20	**C**

Calculation Check

Question 16

λ_{max} = 217 + 30 + 3(5) = 262 nm.

Question 17

For five conjugated double bonds and six alkyl substituents:
λ_{max} = 114 + 6(5) + 5[48 - 1.7(5)] = 341.5 ≈ 342 nm.

Question 18

λ_{max} = 215 + 30 + 10 + 12 + 2(18) [redacted] = [redacted] nm. 303

Question 19

λ_{max} = 202 + 10 + 2(12) + 5 = 241 nm.

Question 20

λ_{max} = 195 + 10 + 2(12) + 5 + 8 = 242 nm.