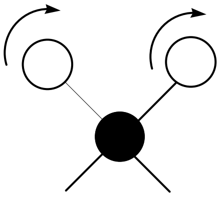
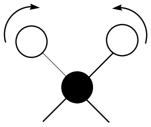
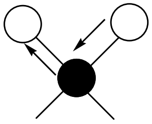
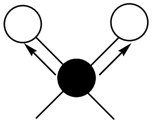
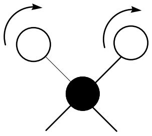
Question No. 1 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question #01	Question 1. Which statement about infrared spectroscopy is ***incorrect***? (A) IR spectroscopy is a method of structure determination based on the amount of infrared light absorbed by a compound. (B) The energy of the photon needed to excite the molecule is based upon the masses of the bonded atoms and the bond strength. (C) Similar functional groups have similar atoms and so they will absorb photons of similar energy. (D) If absorption of energy is to take place, the vibration must not change the dipole moment of the bond.
Feedback on Each Answer Choice	A. Incorrect! One can determine the structure of a compound based on the amount of infrared light that is absorbed by the compound. Go back and review the theory behind infrared spectroscopy.
	B. Incorrect! The bond strength and the masses of the bonded atoms will determine the energy needed to cause an excitation. Go back and review the theory behind infrared spectroscopy.
	C. Incorrect! Since similar functional groups contain similar atoms, they do absorb photons of similar energy. Go back and review the theory behind infrared spectroscopy.
	D. Correct! If absorption of energy is to take place, the vibration must result in a change of the dipole moment of the bond.
Solution	(1) Recall the fundamentals of IR spectroscopy. IR spectroscopy is a method of structure determination based on the amount of infrared light absorbed by a compound. The energy of the photon needed to excite the molecule is based upon the masses of the bonded atoms and the bond strength. Also, absorption of energy is to take place, the vibration must change the dipole moment of the bond. If the vibration does not change the dipole moment of the bond, then the absorption will not be seen. Similar functional groups have similar atoms and so they will absorb photons of similar energy. (2) Read each statement carefully and pick the one that is incorrect in its information. Therefore, the correct answer is (D).

Question No. 2 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question #02	Question 2. Which molecular vibration is depicted as shown?  (A) Asymmetric in-plane bend (B) Symmetric in-plane bend (C) Asymmetric stretch (D) Symmetric stretch
Feedback on Each Answer Choice	A. Correct! This is an example of an asymmetric in-plane bend.
	B. Incorrect! This is not an example of a symmetric in-plane bend. Go back and review the different molecular vibrations seen in IR spectroscopy.
	C. Incorrect! This is not an example of an asymmetric stretch. Go back and review the different molecular vibrations seen in IR spectroscopy.
	D. Incorrect! This is not an example of a symmetric stretch. Go back and review the different molecular vibrations seen in IR spectroscopy.
Solution	(1) Recall the different vibrations of molecules. Six vibrations were listed but we only had to choose from four of them: Symmetric in-plane bend:  Asymmetric stretch:  Symmetric stretch:  Asymmetric in-plane bend:  Therefore the correct answer is (A).

Question No. 3 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question #03	Question 3. Calculate the index of hydrogen deficiency for the formula $C_{10}H_{12}O_2$. (A) 3 (B) 4 (C) 5 (D) 6
Feedback on Each Answer Choice	A. Incorrect! This is not the correct index of hydrogen deficiency. Go back and review how the index is calculated.
	B. Incorrect! This is not the correct index of hydrogen deficiency. Go back and review how the index is calculated.
	C. Correct! The index of hydrogen deficiency for this formula is 5.
	D. Incorrect! This is not the correct index of hydrogen deficiency. Go back and review how the index is calculated.
Solution	(1) Recall the equation for calculating the index of hydrogen deficiency: $I = C + 1 - 1/2H + 1/2N$ (2) Determine C, H, and N: C = number of carbons is molecular formula H = number of hydrogens and halogens N = number of nitrogens and phosphorus In the above example, we were given the formula $C_{10}H_{12}O_2$, so: C = 10 H = 12 (3) Calculate the index of hydrogen deficiency: $I = 10 + 1 - \frac{1}{2}(12) + \frac{1}{2}(0)$ $I = 11 - 6$ $I = 5$ This means that the molecule contains 5 pi bonds, rings or combination of the two. Therefore, the correct answer is (C).

Question No. 4 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question #04	Question 4. Where would you find the absorption due to the stretch of the nitrogen-hydrogen bond of an amine? (A) 400-1450 cm^{-1} (B) 1650-1950 cm^{-1} (C) 2700-3200 cm^{-1} (D) 3200-3700 cm^{-1}
Feedback on Each Answer Choice	A. Incorrect! The region from 400-1450 cm^{-1} is called the fingerprint region and contains many absorptions but not the N-H stretch. Go back and review the IR interpretation trends.
	B. Incorrect! The region from 1650-1950 cm^{-1} is where one finds carbonyl absorptions and aromatic overtones but not the N-H stretch. Go back and review the IR interpretation trends.
	C. Incorrect! The region from 2700-3200 cm^{-1} is where one finds alkane, alkene, and C-H stretches, the aldehyde C-H stretch and the O-H stretch from carboxylic acids but not the N-H stretch. Go back and review the IR interpretation trends.
	D. Correct! The absorption due to the stretching of the N-H bonds of amines is found in the region from 3200-3700 cm^{-1}.
Solution	(1) Recall the absorptions of functional groups from the table given in the tutorial. Once again, you will need to memorize this information as you will be expected to know it on the MCAT. The nitrogen-hydrogen bond absorbs in the 3200-3700 cm^{-1} range. By looking at this region, you can tell the substitution on the nitrogen of the amine. If there is one hydrogen on the nitrogen, you will see one peak in this region. If there are two hydrogens bound to the nitrogen, you will see two peaks in this region. Therefore, the correct answer is (D).

Question No. 5 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question #05	Question 5. Which group usually has the strongest peak of the IR spectrum? (A) alkyne (B) carbonyl (C=O) (C) carbon-carbon double bond (D) carbon-nitrogen triple bond
Feedback on Each Answer Choice	A. Incorrect! Alkynes usually produce weak absorptions and therefore have small, weak peaks. If the alkyne is symmetrically substituted, it may not produce an absorption at all. Go back and review the IR interpretation trends.
	B. Correct! If present in the molecule, the carbonyl group typically has the strongest, most noticeable peak in the IR spectrum.
	C. Incorrect! The carbon-carbon double bond can produce a fairly strong absorption if appropriately substituted. However, it is not usually the strongest in the spectrum. Go back and review the IR interpretation trends.
	D. Incorrect! The carbon-nitrogen triple bond can produce a fairly strong absorption, however, it is not usually the strongest in the spectrum. Go back and review the IR interpretation trends.
Solution	(1) Recall the details of IR absorptions in a spectrum. Absorptions are described as either weak, medium, strong, or very strong. The stronger the absorption, the longer the peak appears in the spectrum. If a carbonyl is present, a very strong absorption occurs in the range of 1650-1950 cm^{-1} which is almost in the center of the spectrum. Very little else absorbs in this area so when such an absorption is present, it is very hard to miss. The carbonyl peak is usually the strongest in the spectrum. Therefore, the correct answer is (B).

Question No. 6 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question #06	Question 6. When approaching an IR spectrum for the first time, what is the first step you do in working to solve the structure that produces it? (A) Calculate the index of hydrogen deficiency. (B) Scan the spectrum and try to pick out obvious absorptions. (C) Think of possible structures from the formula you were given. (D) Consult a frequency table and try to match up absorptions with peaks in the spectrum.
Feedback on Each Answer Choice	A. Correct! By calculating the index of hydrogen deficiency first, you get an idea of what to specifically look for in the IR spectrum.
	B. Incorrect! Scanning for obvious absorptions would not be the best way to approach an IR spectrum to determine the structure of a compound. Review the steps for solving IR spectra.
	C. Incorrect! Thinking of possible structures from the given formula would not be the best way to approach an IR spectrum. Review the steps for solving IR spectra.
	D. Incorrect! Consulting a frequency table and trying to match absorptions would not be the best way to approach an IR spectrum. Review the steps for solving IR spectra.
Solution	(1) Recall the steps for approaching an IR spectrum to determine a molecule's structure. Step 1: Calculate the index of hydrogen deficiency (sometimes called the degrees of freedom in organic textbooks). Step 2: Using the formula and the index of hydrogen deficiency, predict possible functional groups that may be present in the molecule. Step 3: Look for the frequencies for those functional groups in the table of frequencies. Step 4: Confirm those functional groups are present in the IR spectrum, and then draw the structure. Anytime you are asked to determine the structure of a molecule, your first step should be to calculate the index of hydrogen deficiency. Therefore, the correct answer is (A).

Question No. 7 of 10

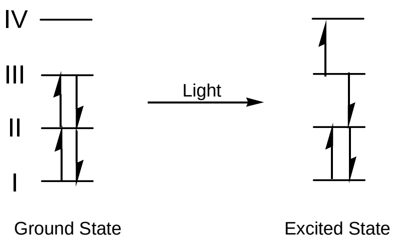
Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question #07	Question 7. What region of the electromagnetic spectrum corresponds to 200-400 nm? (A) visible (B) infrared (C) ultraviolet (D) microwave
Feedback on Each Answer Choice	A. Incorrect! The visible region of the spectrum ranges from 400-700 nm. Review the regions of the electromagnetic spectrum.
	B. Incorrect! The infrared region of the spectrum ranges from 0.7-100 μm. Review the regions of the electromagnetic spectrum.
	C. Correct! The region from 200-400 nm is the ultraviolet region of the electromagnetic spectrum.
	D. Incorrect! The microwave region of the spectrum ranges from 1 mm to 1m. Review the regions of the electromagnetic region.
Solution	(1) Recall the electromagnetic spectrum. The spectrum ranges from radio waves (the least energetic) to gamma rays (the most energetic). You will need to know the types of radiation present in the spectrum, their relative energies, and their approximate wavelengths. The region of the electromagnetic spectrum that corresponds to 200-400 nm is the ultraviolet region. Therefore, the correct answer is (C).

Question No. 8 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question #08

Question 8. Which level represents the HOMO of the ground state in the diagram shown?



(A) I
(B) II
(C) III
(D) IV

Feedback on Each Answer Choice

A. Incorrect!
I is not the HOMO. What does HOMO stand for? Go back and review electronic transitions.

B. Correct!
The HOMO, the highest occupied molecular orbital, is labeled as II.

C. Incorrect!
III is not the HOMO. What does HOMO stand for? Go back and review electronic transitions.

D. Incorrect!
IV is not the HOMO. What does HOMO stand for? Go back and review electronic transitions.

Solution

(1) Recall the definitions for HOMO and LUMO.

HOMO stands for the highest occupied molecular orbital.
LUMO stands for the lowest unoccupied molecular orbital.

(2) Figure out what the diagram is depicting.

The diagram shows the different molecular orbitals in a molecule. In the ground state, the bottom two are filled. When the molecule absorbs energy, one of the electrons is kicked into a higher energy molecular orbital.

(3) Based on the definitions of HOMO and LUMO, determine which level is the HOMO.

Since the HOMO is the highest occupied molecular orbital, look for the highest level with electrons in it. This would be level II.

Therefore, the correct answer is (B).

Question No. 9 of 10

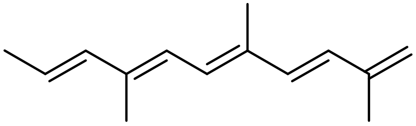
Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.	
Question #09	Question 9. Which statement below about UV-Vis absorptions is ***incorrect***? (A) Absorption of visible or UV light occurs when there is an electronic transition in the molecule that is equal in energy to the incident radiation. (B) The transition usually is the movement of a single electron from the LUMO to the HOMO. (C) The frequency of absorption is dependent on the difference in energy between the HOMO and LUMO. (D) Conjugation in a molecule decreases the energy gap between the HOMO and the LUMO.
Feedback on Each Answer Choice	A. Incorrect! When there is an electronic transition of equal energy to the incident radiation, an absorption of visible or UV light will occur. Review the details of UV/Vis spectroscopy.
	B. Correct! The transition is usually the movement of a single electron from the highest occupied orbital, the HOMO, to the lowest unoccupied orbital, the LUMO.
	C. Incorrect! The difference in energy between the HOMO and LUMO will dictate the frequency of the absorption needed to cause an electronic transition. Review the details of UV/Vis spectroscopy.
	D. Incorrect! Conjugation will decrease the energy gap between the HOMO and the LUMO in a molecule.
Solution	(1) Recall the background and theory of UV-Vis spectroscopy. UV-Vis spectroscopy looks at the electronic excitations of a molecule when it absorbs visible or UV light. Absorption of visible or UV light occurs when there is an electronic transition in the molecule that is equal in energy to the incident radiation. The transition usually is the movement of a single electron from the HOMO to the LUMO. The frequency of absorption is dependent on the difference in energy between the HOMO and LUMO. Conjugation in a molecule decreases the energy gap between the HOMO and the LUMO causing the energy required for the transition to be lower in energy. Therefore, the correct answer is (B).

Question No. 10 of 10

Instructions: (1) Read the problem and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question #10

Question 10. Estimate the λ_{max} for the compound shown:



(A) 307-337 nm
(B) 327-357 nm
(C) 387-437 nm
(D) 438-487 nm

Feedback on Each Answer Choice

A. Incorrect!
According to the rules established by Woodward and Fieser, this compound would not have a λ_{max} in this range. Go back and review their rules for predicting λ_{max}.

B. Correct!
Based on the Woodward-Fieser rules, we can predict this conjugated compound would have a λ_{max} of approx. 327-357 nm.

C. Incorrect!
According to the rules established by Woodward and Fieser, this compound would not have a λ_{max} in this range. Go back and review their rules for predicting λ_{max}.

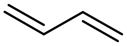
D. Incorrect!
According to the rules established by Woodward and Fieser, this compound would not have a λ_{max} in this range. Go back and review their rules for predicting λ_{max}.

Solution

(1) Recall the Woodward-Fieser method for approximating λ_{max}.

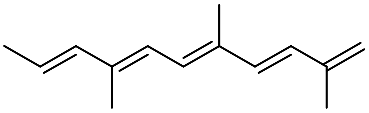
Woodward and Fieser, using 1,3-butadiene (pictured below) as a baseline, empirically noted that each additional conjugated double bond in a molecule added 30-40 nm to the λ_{max}. They also noted that an alkyl group directly bonded to a double bond added about 5 nm to the λ_{max}.

Baseline:



λ_{max} = 217 nm

(2) Compare given compound to 1,3-butadiene.



The given compound has three more conjugated double bonds than 1,3-butadiene and four alkyl groups attached to various double bonds.

(4) Do the math.

Alkyl groups: 4 x 5nm = 20 nm
Double bonds are given as a range so we do the calculation for each end of the range:
3 x 30 nm = 90nm
3 x 40 nm = 120 nm

Add these numbers to the λ_{max} of 1,3-butadiene. Again, since there is a range of numbers, we will do the calculation for both ends of the range.

217 nm + 20 nm + 90 nm = 327 nm
217 nm + 20 nm + 120 nm = 357 nm

The λ_{max} of this molecule should fall within the range of 327 nm – 357 nm.

Therefore, the correct answer is (B).