Question 1
MC100

Which of the following best describes BOTH a picture of $\Psi$ for the bonding molecular orbital between nitrogen and the carbon of the –CH$_3$ group, AND a picture of $\Psi^2$ for the N-H bonding molecular orbital in the recreational drug Ketamine, structure shown.

The colors, and thus implied phasing in wavefunctions, is arbitrary. A change in color imples a change in phase (equivalent to going from shaded to non-shaded or vice versa), which is the same as saying a change in sign of the wavefunction from positive to negative or the other way round. Remember, the wavefunctions really do change sign (positive/negative), but we don't use the terms positive and negative, since it is easy to confuse with positive and negative charge, and also the actual sign of the wavefunction, positive or negative, is arbitrary.

Anyway, the blue/green colored "pictures" imply wavefunctions, since they show the phase information that wavefunctions posess. The grey "pictures" imply wavefunctions squared (probabilities), since they contain no phase information (they are just a single color). Thus C and D can’t be the correct answers, since for the N-H bond we are looking for pictures of wavefunctions squared.

B is better than A since it shows the wavefunction for the C-N bonding orbital to be larger towards the more electronegative nitrogen.
The non-nutritive sweetener neotame, shown below, is ca. 7000 times sweeter than sugar.

The functional groups in neotame include:
A = 1 acid, 2 amides, 1 aromatic
B = 2 amines, 1 ester, 1 aromatic
C = 1 ester, 1 amine, 1 aromatic
D = 1 ester, 1 acid, 1 alcohol

these are not ketones, because they are part of an ester, amide, or carboxylic acid
this is not an ether, because it is part of an ester

An amine can be primary ($1^\text{Y}$), secondary ($2^\text{Y}$) or tertiary ($3^\text{Y}$).

A nitrogen a to (next to) a carbonyl is an amide. Amides are primary ($1^\text{Y}$), secondary ($2^\text{Y}$) or tertiary ($3^\text{Y}$).
**Question 3**

MCbdea

For the specific C-H bonds numbered 1 - 4 in the following structure, which would be the expected order of bond LENGTHS, from longest to shortest?

A 3 > 1 > 2 ~ 4  
B 4 > 2 > 3 ~ 1  
C 1 > 2 > 3 > 4  
D 4 ~ 2 > 1 > 3

stronger bonds are generally shorter bonds, the order of bond strength is as follows

sp3 carbon, makes 3° radical, weakest  
sp2 carbon, 2nd strongest  
sp carbon, strongest  
sp3 carbon, makes 2° radical, 2nd weakest

the difference in bond strengths is quite small for the 2 C(sp3)-H bonds, and thus the difference is length is also small

the actual difference in bond lengths for C(sp3)-H and C(sp2)-H is also not very big, but the direction C(sp3)-H > C(sp2)-H is pretty clear

the shortest bond is expected to be the strongest bond, and it is
Question 4

Which energy diagram best described the energy diagrams for homolytic cleavage of the 4 indicated bonds C-Ha, C-Hb and C-Hc?
Question 5

MC10ab

which correctly describes the respective degrees of unsaturation for the following four compounds?

1. Cadaverine, C₅H₁₄N₂, foul-smelling, found in dead tissue
2. Zingerone, C₁₁H₁₄O₂, hot-tasting compound found in ginger
3. Adapalene, C₂₈H₂₈O₃, used to treat acne
4. Miconazole, C₁₈H₁₄Cl₄N₂O, an anti-fungal agent

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadaverine, Cadaverine, foul-smeeding molecule formed in dead tissue</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Zingerone</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Adapalene</td>
<td>14</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Miconazole</td>
<td>11</td>
<td>10</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

Degrees of unsaturation

- Cadaverine, no rings, no double bonds
  - max # hydrogens = (6"C"*2)+2 = 14
  - actual # "hydrogens" = 14
  - degrees = (14-14)/2 = 0

- Zingerone, 4 double bonds and 1 ring
  - max # hydrogens = (11C*2)+2 = 24
  - actual # "hydrogens" = 14
  - degrees = (24-14)/2 = 5

- Adapalene, 9 double bonds and 6 rings
  - max # hydrogens = (28C*2)+2 = 58
  - actual # "hydrogens" = 28
  - degrees = (58-28)/2 = 15

- Miconazole, 8 double bonds and 3 rings
  - max # hydrogens = (19"C"*2)+2 = 40
  - actual # "hydrogens" = 14 + 4 = 18
  - degrees = (40-18)/2 = 11
**Question 6**

**MCdipole2**

Which has the LARGEST BOND dipole moment? (select the bond with the largest bond dipole moment in each structure, then compare these to determine the largest overall)

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the question asks about BOND dipole moments ONLY, not molecular dipole moments, we do need to concern ourselves with cancelling bond dipoles here

A

large electronegativity difference between C and O, π-electrons are highly polarizable, largest bond dipole moment

B

large electronegativity difference between C and O and H and O, σ-electrons in each bond are polarized, but not as strongly as the π-electrons in A

C

only C-C and C-H bonds, all bond dipole moments are negligible

D

moderate electronegativity difference between C and N, π-electrons are highly polarizable, but not not as large as a C=O bond due to smaller electronegativity difference, the N-H dipol moment will be even smaller as a consequence of less polarizable σ-bonding electrons
My mother used to take Ramipril to control high blood pressure. The functional groups in Ramipril INCLUDE

A one alcohol, one ester, one amide
B one amide, one carboxylic acid, one aromatic
C one amine, one carboxylic acid, one ether
D one ester, one aromatic, one alcohol
**Question 8**

How many different isomeric structures with the molecular formula $C_6H_{12}O$ can you draw, where each structure MUST contain the KETONE functional group?

<table>
<thead>
<tr>
<th></th>
<th>A 4</th>
<th>C 6</th>
<th>B 5</th>
<th>D 7</th>
</tr>
</thead>
</table>

- degrees of unsaturation = ONE
  - $(6C \times 2) + 2 = 14$ H maximum : actual H = 12H
  - therefore ONE degree of unsaturation
  - the C=O bond of the ketone "uses" this degree of unsaturation
  - therefore there can be NO double bonds in addition to the C=O bond of the ketone, and there can be no rings

- a ketone must have TWO carbons attached to the carbon of a C=O bond

these are all of the ones I can come up with.....

(non-bonding electrons not included for clarity)

![Ketone Structures](attachment:image.png)