

Please read and sign the Honor Code statement below:

I pledge that on my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this exam.

\_\_\_\_\_  
Signature

**General Instructions:** There are 20 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-20) is worth **5 points** and has **only one correct answer**. Bubble in your answers to these questions on the Scantron provided. **Only the Scantron will be graded, not anything that you write on the exam.**

At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

Good luck!

1A 2A 3A 4A 5A 6A 7A 8A

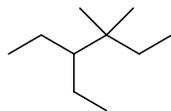
hydrogen 1 H 1.0079																				helium 2 He 4.0026						
lithium 3 Li 6.941	beryllium 4 Be 9.0122																				boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305																				aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80									
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	nickel 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29									
cesium 55 Cs 132.91	barium 56 Ba 137.33	* 57-70 Lu 174.97	hafnium 71 Hf 178.49	tantalum 72 Ta 180.95	wolfram 73 W 183.84	rhenium 74 Re 186.21	osmium 75 Os 190.23	iridium 76 Ir 192.22	platinum 77 Pt 195.08	gold 78 Au 196.97	mercury 79 Hg 200.59	thallium 80 Tl 204.38	lead 81 Pb 207.2	bismuth 82 Bi 208.98	polonium 83 Po [209]	astatine 84 At [210]	radon 85 Rn [222]									
francium 87 Fr [223]	radium 88 Ra [226]	** 89-102 Ac [227]	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]										

\* Lanthanide series

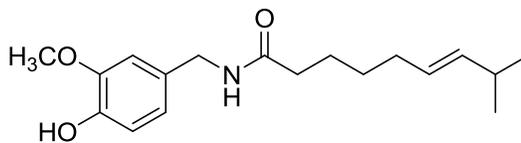
\*\* Actinide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

1. Select the correct name of this molecule.



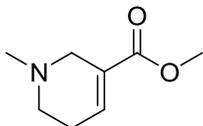
- a. 3-ethyl-4,4-dimethylhexane  
b. 4-ethyl-3,3-dimethylhexane  
c. 3,3-dimethyl-4-ethylhexane  
d. 2-methyl-2,3-diethylpentane  
e. 2,3-diethyl-2-methylpentane
2. Capsaicin is one of the substances in chili peppers that is responsible for their “heat”. Select the functional group that is **not** present in capsaicin.



**Capsaicin**

- a. Amide  
b. Ester  
c. Alkene  
d. Aromatic ring  
e. All of these groups are present in capsaicin
3. In the structure of capsaicin shown in #2, the lone pairs are not explicitly drawn, but all atoms are neutral. How many lone pairs of electrons are there in the structure?
- a. 4  
b. 5  
c. 6  
d. 7  
e. Enough
4. 2-Pentanol (Pentan-2-ol) is a member of a set of constitutional isomers. Which of these molecules is **not** a constitutional isomer of 2-pentanol?
- a. 2-methyl-2-butanol  
b. 1-pentanol  
c. 3-methyl-2-butanol  
d. 3-pentanol  
e. All of these molecules are constitutional isomers of 2-pentanol.

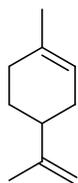
5. Arecoline is a natural product called an alkaloid. It is found in the fruit of the areca palm and is used as a veterinary drug to control worms in animals. In the structure of arecoline shown here, lone pairs of electrons are not explicitly drawn, but all atoms are neutral.



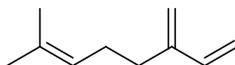
**Arecoline**

Which of the following statements a-d about arecoline is **false**?

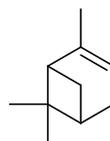
- Arecoline contains a tertiary amine.
  - The C-N  $\sigma$  bonds in arecoline are formed by the overlap of  $sp^3$  orbitals on carbon and nitrogen.
  - A resonance structure may be drawn for arecoline that places a formal positive charge on nitrogen.
  - There are 13 hydrogen atoms in arecoline.
  - More than one of the statements above (a, b, c, d) is false.
6. Termites are not very nice in many ways. In addition to eating wood and destroying structures, certain termites use a chemical defense mechanism called a *fontanellar gun*, where a termite sprays an enemy insect with a toxic mixture of these three compounds:



**Limonene**



**Myrcene**

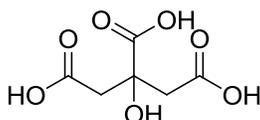


**Pinene**

Each of these compounds contains one or more carbon-carbon double bonds. What is the percentage of s character for the hybrid orbitals on a carbon involved in a double bond?

- 25%
- 33.3%
- 50%
- 66.7%
- 75%

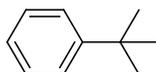
7. Which statement about the compounds in question 6 is **true**?
- Two of the compounds are constitutional isomers of each other, but the third is not.
  - All three compounds are constitutional isomers of each other.
  - The three compounds are *not* constitutional isomers of each other.
  - There is not enough information to answer the question.
8. Citric acid is a compound that occurs naturally in citrus fruits. It is also an important metabolic intermediate in all aerobic organisms (organisms that can survive in an oxygenated environment).



**Citric acid**

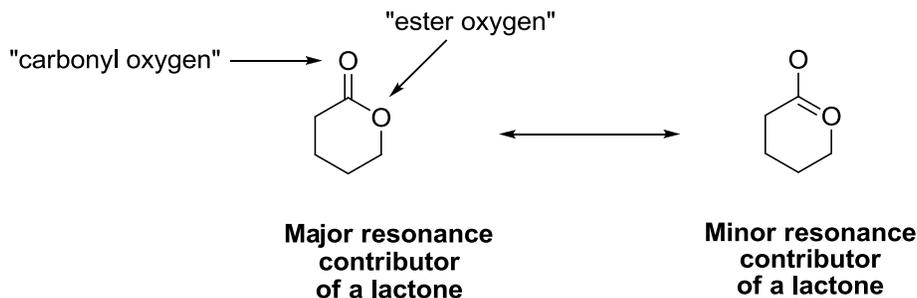
Select the correct statement about the structure of citric acid.

- Citric acid contains a tertiary alcohol.
  - There is an anhydride functional group in citric acid.
  - There is an ester functional group in citric acid.
  - The only functional groups contained in citric acid are carboxylic acids.
  - Citric acid contains a C-C  $\pi$  bond.
9. The common name for the group attached to this benzene ring is



- isopropyl
- sec*-butyl
- tert*-butyl
- isobutyl
- neobutyl

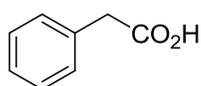
10. One of the functional groups we discussed in class was an ester. Esters can occur as cyclic structures called *lactones*.



In the structures above, lone pairs are not explicitly drawn. In the major resonance contributor, all atoms are neutral. Which of the following correctly describes the formal charges in the minor resonance contributor shown above?

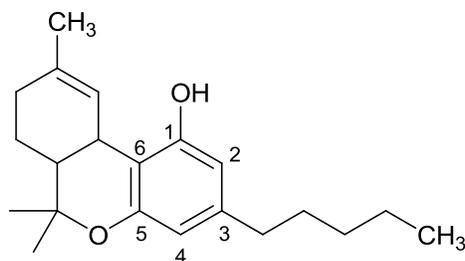
	Ester oxygen	Carbonyl oxygen	Carbonyl carbon
<b>A</b>	+	-	0
<b>B</b>	-	+	0
<b>C</b>	0	-	+
<b>D</b>	0	+	-
<b>E</b>	None of the answer choices A-D is correct.		

11. Which of these functional groups is contained in this structure?



- Alcohol
- Aldehyde
- Amine
- Carboxylic acid
- None of these

12. Tetrahydrocannabinol (THC) is a compound you saw in class. Some of the carbon atoms are numbered in the structure for reference. Lone pairs are not explicitly drawn, but all atoms are neutral.

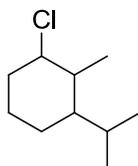


**Tetrahydrocannabinol**

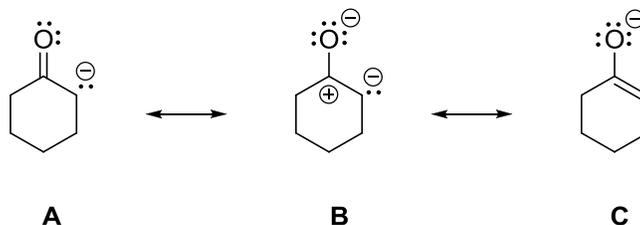
- According to valence bond theory, what orbitals are overlapping to form the  $\sigma$  bond between C1 and C6?
- $sp$  and  $sp$
  - $sp^2$  and  $sp^2$
  - $sp^3$  and  $sp^3$
  - $p$  and  $p$
13. Although the structure shown in #12 is the major resonance contributor of tetrahydrocannabinol, the molecule can be represented with several other resonance contributors. All these contributors involve the delocalization of electrons into the aromatic ring from the O in the OH group or from the O in the ether functional group. Which of the following accurately describes one of the acceptable minor contributors?

	Ether oxygen	OH oxygen	C1	C2	C3	C4	C5	C6
<b>A</b>	+	0	-	0	0	0	0	0
<b>B</b>	0	+	0	0	0	-	0	0
<b>C</b>	+	0	0	0	-	0	0	0
<b>D</b>	0	+	0	0	0	0	-	0
<b>E</b>	None of the answer choices A-D represents an acceptable minor resonance contributor.							

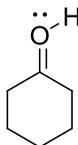
14. Which of the choices is the correct common name for this compound?  
(Note that it's a common name, not an official IUPAC name, because we're using the common name for the isopropyl group.)



- a. 1-chloro-3-isopropyl-2-methylcyclohexane  
 b. 1-chloro-2-methyl-3-isopropylcyclohexane  
 c. 3-chloro-1-isopropyl-2-methylcyclohexane  
 d. 1-isopropyl-2-methyl-3-chlorocyclohexane  
 e. 3-chloro-2-methyl-1-isopropylcyclohexane
15. Select the *most minor* (least important) resonance contributor. All lone pairs are shown in all structures.

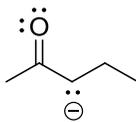


- a. A  
 b. B  
 c. C  
 d. A and C  
 e. All structures are equivalent
16. What is the formal charge on oxygen in this structure? All lone pairs of electrons are shown.

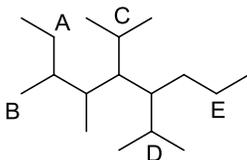


- a. 0  
 b. +1  
 c. -1  
 d. +2  
 e. -2

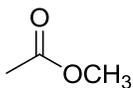
17. How many hydrogen atoms are there in this structure?



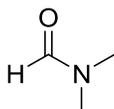
- a. 7
  - b. 8
  - c. 9
  - d. 10
  - e. Some other number
18. Some of the carbons in this structure are labeled. Which of them is a primary carbon?



19. Which of these compounds is **not** a carboxylic acid derivative?



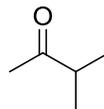
A



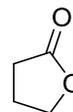
B



C

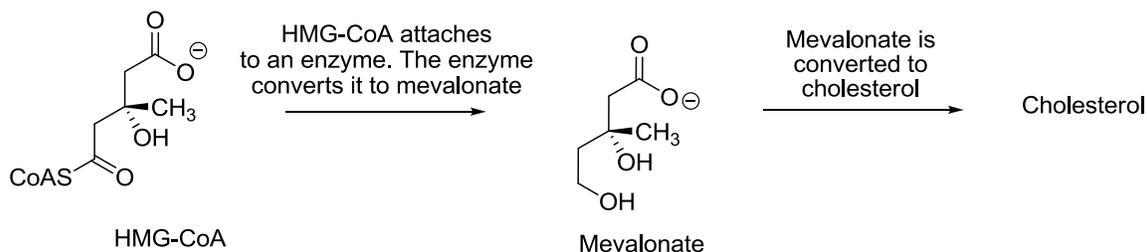


D

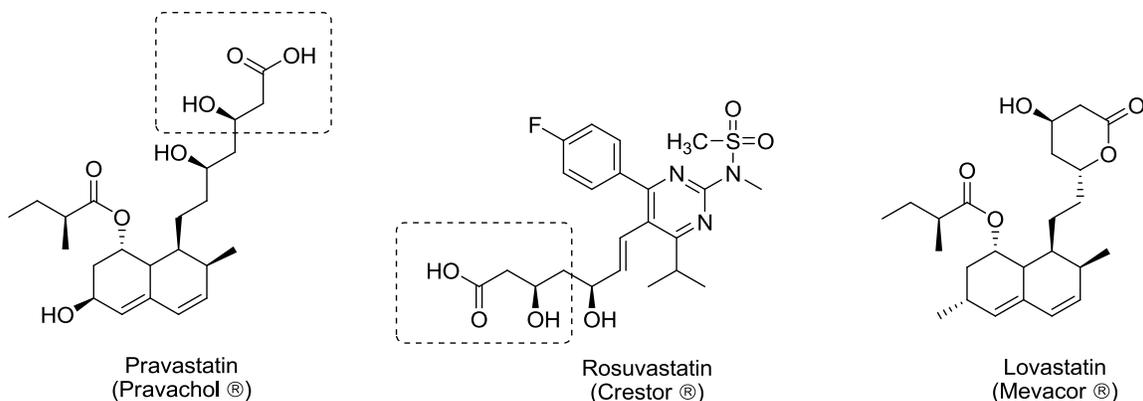


E

20. Statins are a commonly prescribed class of drugs that reduce risk of heart disease by lowering blood cholesterol levels. One of the important steps in cholesterol production in the body is the conversion of a chemical called HMG-CoA to mevalonate. This change is accomplished using an enzyme. HMG-CoA attaches to the enzyme and is converted to mevalonate. Mevalonate is then converted to cholesterol in later steps:



Statin drugs work because they mimic part of the structure of HMG-CoA, so they can attach to the enzyme in the way that HMG-CoA would. This blocks HMG-CoA from attaching to the enzyme, which decreases the production of mevalonate and thus prevents the synthesis of cholesterol. Most statin drugs, like Pravastatin and Rosuvastatin (shown below) contain the part of the drug that mimics HMG-CoA (circled with a dashed line). However, in the drug Lovastatin, that portion of the molecule does not appear, yet Lovastatin still works to reduce cholesterol.



Which of the following choices offers the most reasonable explanation for this apparent discrepancy, using information you have heard in lecture?

- Resonance in Lovastatin allows its atoms to rearrange to fit into the enzyme
- The presence of the cyclic ester (lactone) functional group in Lovastatin
- Lovastatin is a constitutional isomer of the other statin drugs
- Lovastatin has the same number of  $sp^2$  carbons as the other statin drugs

21. **Survey question (no credit).** Select the statement that best describes your plans or situation at this moment in time. Thank you for your response!
- a. I do not plan to take O-Chem 2 (it's not required by my major, program or personal plans).
  - b. I plan to take O-Chem 2 this summer with Dr. Minger.
  - c. I plan to take O-Chem 2 in the fall or spring semester at CU Boulder.
  - d. I plan to take O-Chem 2 in the fall or spring semester at another institution.