

Please read Honor Code statement below
and sign your Scantron in the box on front:

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.

General Instructions: There are 25 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-25) is worth **4 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 signed Scantron. You may keep the exam to check your answers against the key later.

Good luck!

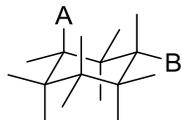
1A 2A 3A 4A 5A 6A 7A 8A

hydrogen 1 H 1.0079	beryllium 4 Be 9.0122											helium 2 He 4.0026						
lithium 3 Li 6.941		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	selecnium 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	palladium 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 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	* 89-102 *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dundelium 105 Db [262]	seaborgium 106 Sg [263]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	unnilium 110 Uun [271]	ununium 111 Uuu [272]	unbibium 112 Uub [277]	ununquadium 114 Uuq [289]					

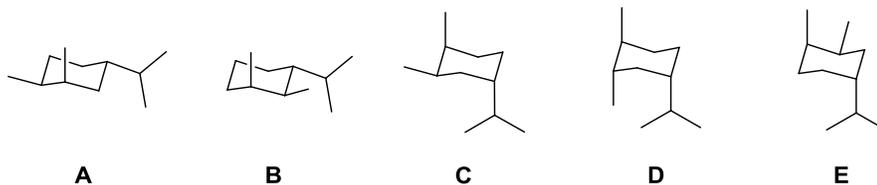
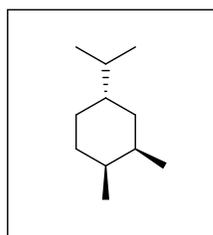
* Lanthanide series

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]

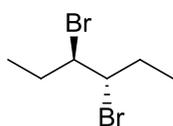
1. Select any and all true statements about this structure:



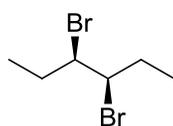
- The groups A and B are cis.
 - The groups A and B are trans.
 - The groups A and B are gauche.
 - The groups A and B are anti.
 - More than one of these statements is true.
2. Select the structure that represents the *less* stable chair conformation of the molecule in the box.



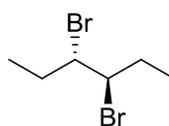
Questions 3, 4, 5 and 6 all relate to the following set of structures.



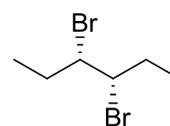
W



X



Y



Z

3. Which of these structures is/are chiral?

- X and Z
- W and Y
- Only X
- Only W
- All four structures are chiral

4. Which of these structures are achiral and meso?

- a. X and Z
- b. W and Y
- c. Only X
- d. Only W
- e. All four structures are achiral and meso

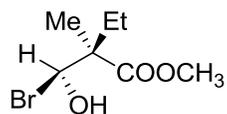
5. Which of these pairs are enantiomers?

- a. W and X
- b. W and Y
- c. W and Z
- d. X and Z
- e. Both b and d

6. Which of these pairs are identical?

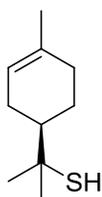
- a. W and X
- b. W and Y
- c. W and Z
- d. X and Z
- e. Both b and d

7. In the structure shown, which of the indicated groups is **anti** to the OH group?

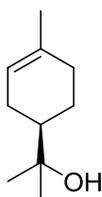


- a. H
- b. Br
- c. Me
- d. Et
- e. COOCH₃

8. Grapefruit mercaptan (pK_a 10) is a natural product found in grapefruit. Alpha-terpineol is another natural product found in a variety of plant sources and used in perfumery. When each of these compounds is treated with sodium hydroxide, a proton transfer occurs. Which reaction has the larger equilibrium constant?

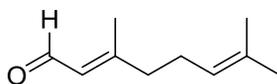


Grapefruit mercaptan



α -Terpineol

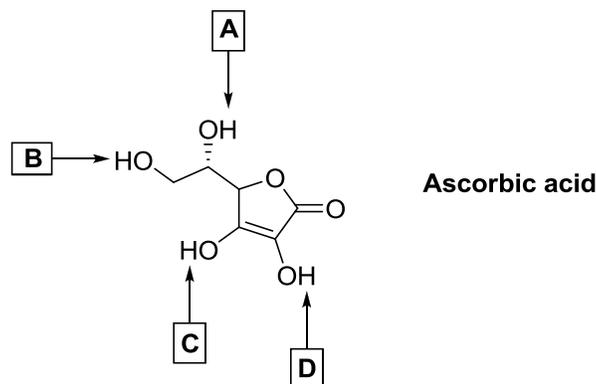
- a. The reaction of sodium hydroxide and grapefruit mercaptan
b. The reaction of sodium hydroxide and α -terpineol
c. Both reactions will have roughly the same equilibrium constant
d. There is not enough information available to answer the question
9. Geranial is a natural product that is a component of the oils of various plants. Which of the following stereochemical labels will appear in the IUPAC name for geranial?



Geranial

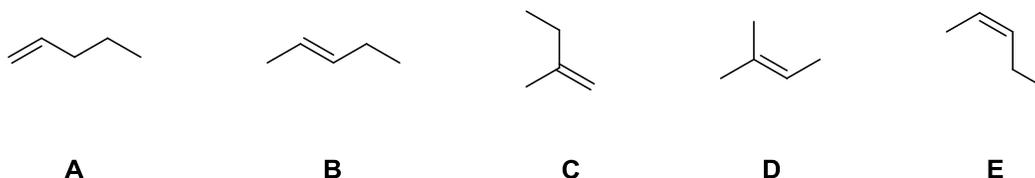
- a. *R*
b. *S*
c. *E*
d. *Z*
e. More than one of these

10. Ascorbic acid is one form of Vitamin C. Four of its protons are labeled in the structure below. Which of these protons is most acidic?



11. In the structure of ascorbic acid in question 10, proton "A" is part of a hydroxyl (OH) group that is attached to an asymmetric carbon. What is the absolute configuration at this asymmetric carbon?

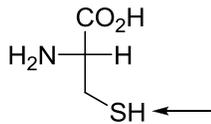
- a. *R*
 - b. *S*
12. Which of these alkene isomers is most stable?



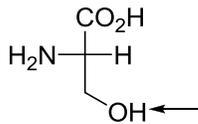
13. Two of the alkene isomers in question 12, when treated with sulfuric acid and water, will give the same single product. Which two?

- a. A and B
 - b. C and D
 - c. B and E
 - d. A and D
 - e. C and E
14. Two of the alkene isomers in question 12, when treated with HBr, would give a mixture of products rather than only one product. Which two?
- a. A and B
 - b. C and D
 - c. B and E
 - d. A and D
 - e. C and E

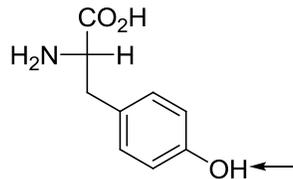
15. Here are three amino acids, drawn as Fischer projections:



cysteine



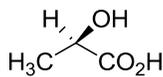
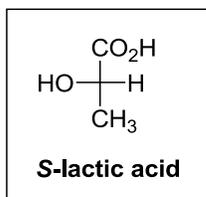
serine



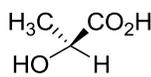
tyrosine

In each structure, the proton on the amino acid's "side chain" is designated with an arrow. In which of these amino acids is the side chain *least* acidic?

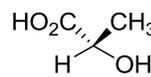
- Cysteine
 - Serine
 - Tyrosine
 - All three are equally acidic
16. *S*-Lactic acid, a chiral compound, is produced during normal metabolism and exercise. Which of these molecules, when combined with *S*-lactic acid, could produce a racemic mixture?



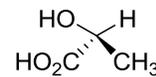
A



B

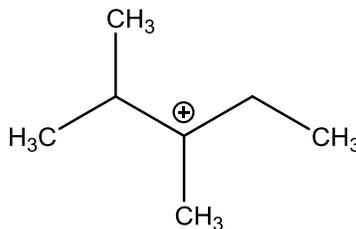


C



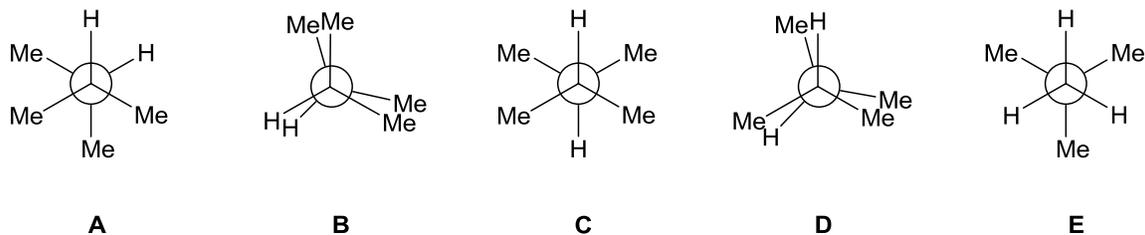
D

17. Hyperconjugation is one of the ways that carbocations can be stabilized. Which of the following pairs of orbitals is/are NOT participating in this type of stabilization for the carbocation shown below?

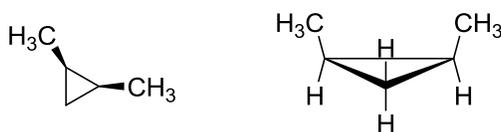


- C-H σ and p
- C-C σ and p
- C-H σ^* and p
- Both a and b
- a, b, and c

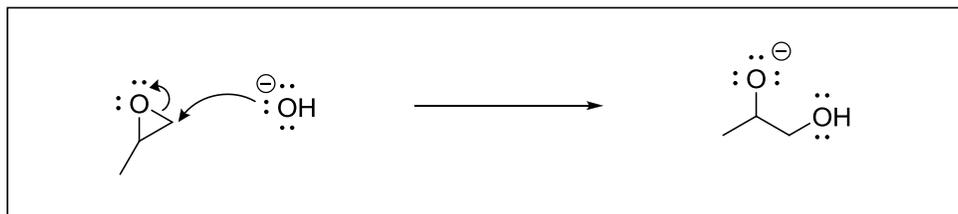
18. Which of these Newman projections shows the most stable conformation of 2,3-dimethylbutane looking down the C2-C3 bond?



19. What types of strain do you expect to be present in this molecule? The structure is drawn in two different ways to help you visualize.



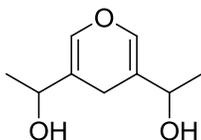
- Torsional
 - van der Waals
 - Angle
 - Torsional and angle
 - All three types of strain
20. Here is a reaction that you will see shortly:



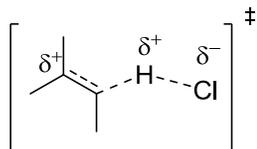
In this reaction, hydroxide ion is acting as a nucleophile and attacking an epoxide (the electrophile). This causes the three-membered ring to open. What is the LUMO in this process?

- Nonbonding MO in hydroxide ion
- OH σ
- CO σ
- CO σ^*
- Nonbonding MO or p orbital in the epoxide

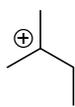
21. We saw in class that one example of a 1,3-diaxial interaction is when there are two axial methyl groups on the same side of a cyclohexane ring, called a *syn* pentane interaction. For *cis*-1,3-dimethylcyclohexane, the difference in energy between the two chair conformations is 5.3 kcal/mol. Given that the energy of a gauche butane interaction is 0.8 kcal/mol, what is the energy value (in kcal/mol) of the *syn* pentane interaction?
- 2.1
 - 2.9
 - 3.7
 - 4.5
 - Cannot be determined with the available information
22. How many stereoisomers exist for this constitution?



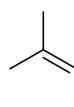
- 1
 - 2
 - 3
 - 4
23. Select the least stable chemical species.



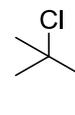
A



B

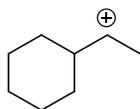


C

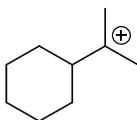


D

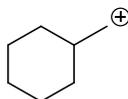
24. Select the least stable carbocation.



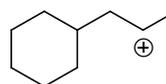
A



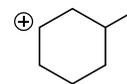
B



C



D

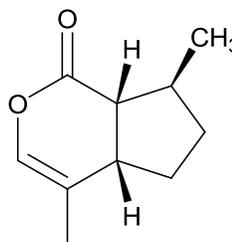
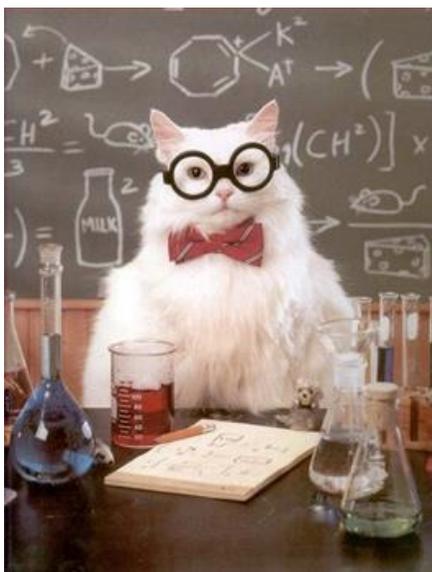


E

25. Recently, in a concert in Canada, Justin Bieber fell off the stage. Here is a direct quotation from the news article reporting this fact: "During the 22-year-old pop star's Saskatchewan, Canada concert, he fell right off the edge of the stage while adjusting his pants between songs." (You can't make this stuff up.)

Authorities suspect that someone placed an intoxicating substance in Bieber's energy drink, which resulted in his tumble off the stage. The prime suspect is the Chemistry Cat. It is believed that the Chemistry Cat secretly spiked Bieber's drink with a massive dose of nepetalactone, the active ingredient in catnip, and that Bieber had an unfavorable reaction to this compound.

Which statement best describes the hybridization of the oxygen atoms in nepetalactone? (Lone pairs are not explicitly drawn; all atoms are neutral.)



nepetalactone

- Both are sp^2 hybridized
- Both are sp^3 hybridized
- The carbonyl oxygen is sp^2 and the ester oxygen is sp^3
- The carbonyl oxygen is sp^3 and the ester oxygen is sp^2