

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 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 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

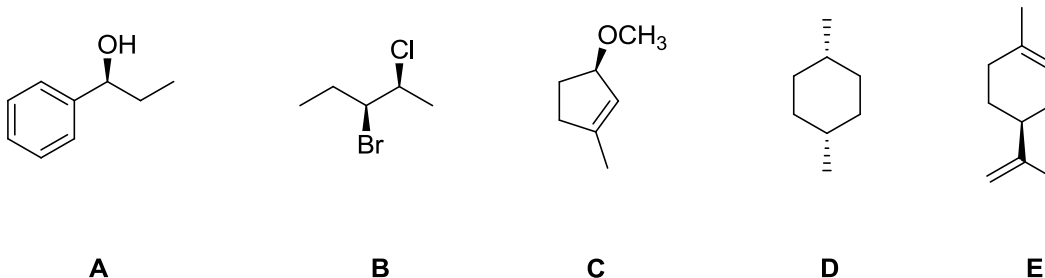
hydrogen 1 H 1.0079																							helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122																						neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305																						argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 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	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 *	lanthanum 57 La 138.91	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 **	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

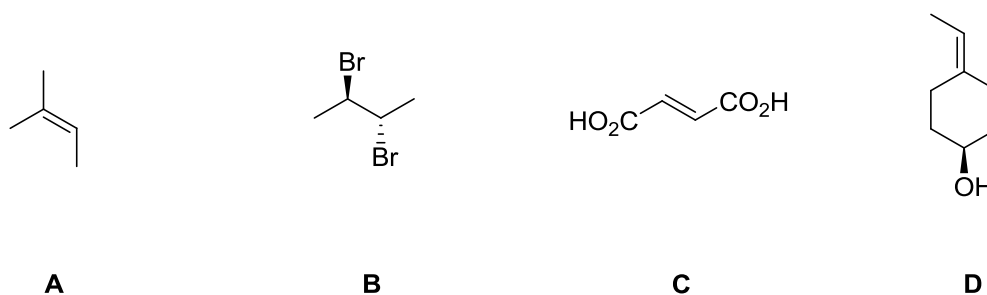
** Actinide series

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]

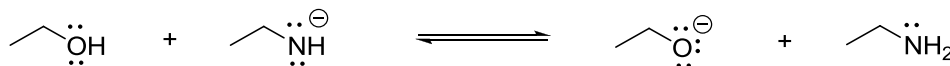
1. Which of these compounds has an asymmetric carbon with an absolute configuration of *R*?



2. Which of these structures is achiral and meso?

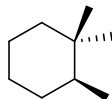


3. Which side of this Bronsted-Lowry acid base reaction is favored at equilibrium? (Spectator ions are omitted for clarity.)

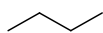


- Reactants (left side of equation)
 - Products (right side of equation)
 - Neither side is favored. There are equal amounts of reactants and products present at equilibrium.
 - There is not enough information available to answer the question.
4. HF and HBr are both Bronsted acids. We have explored stabilization in the conjugate base to explain acidity. For this pair of acids, which of the following ideas is the best to explain which conjugate base is more stable?
- Resonance
 - Electronegativity
 - Polarizability/Size
 - Luminescence
 - Hybridization

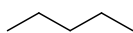
5. What is the approximate difference in energy between the two chair conformations of this molecule?



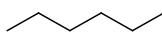
- a. 0.8 kcal/mol
 b. 1.6 kcal/mol
 c. 2.4 kcal/mol
 d. 3.2 kcal/mol
 e. There is no energy difference between the two chair conformers.
6. Which of the following molecules is heptane?



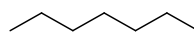
A



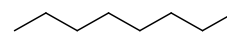
B



C

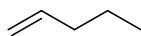


D

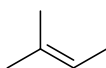


E

7. Which of these alkenes releases the least amount of energy on formation from its elements (all substances in the standard state)?



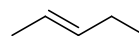
R



S



T



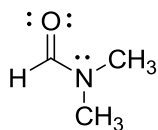
U

- a. R
 b. S
 c. T
 d. U
 e. Cannot be determined

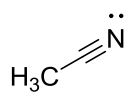
8. Which of these molecules cannot be a hydrogen bond donor?



A



B



C

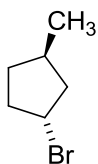
All of these molecules can be hydrogen bond donors

D

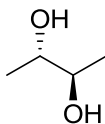
None of these molecules can be hydrogen bond donors

E

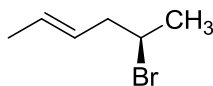
9. Which of these compounds is chiral?



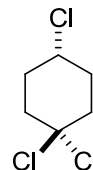
J



K

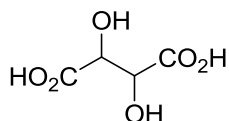


L



M

- a. J
 b. J, L
 c. J, K, L
 d. J, L, M
 e. J, M
10. Select the correct statement about the set of stereoisomers that can be generated from this constitution.

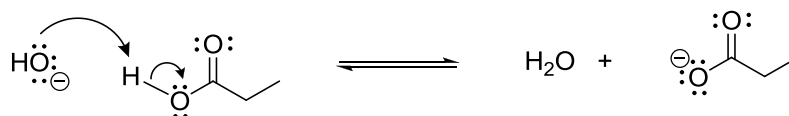


- a. The set contains 4 chiral molecules
 b. The set contains 2 chiral molecules and 2 achiral molecules
 c. The set contains 2 chiral molecules and 1 achiral molecule
 d. The set contains 1 chiral molecule and 1 achiral molecule
 e. The set contains 2 achiral molecules
11. Use the table of energies provided to calculate the barrier to rotation around C1-C2 in 1-bromopropane.

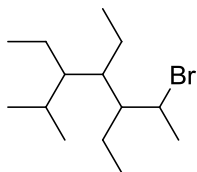
Interaction	Energy (kcal/mol)
H-H eclipse	1.0
CH ₃ -H eclipse	1.3
Br-H eclipse	1.5
Br-CH ₃ gauche	1.0
Br-CH ₃ eclipse	3.0
Br-CH ₃ anti	0

- a. 2.8 kcal/mol
 b. 3.8 kcal/mol
 c. 4.0 kcal/mol
 d. 5.0 kcal/mol
 e. None of these values

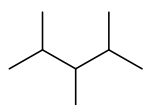
12. The frontier orbitals are the ones that interact in a chemical reaction. Which of these statements correctly identifies the frontier orbitals in this reaction? (The name of the carboxylic acid is propanoic acid.)



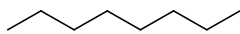
- HOMO: sp^2 on O in hydroxide
LUMO: p on O in propanoic acid
 - HOMO: sp^3 on O in hydroxide
LUMO: p on O in propanoic acid
 - HOMO: sp^3 on O in propanoic acid
LUMO: sp^3 on O in hydroxide
 - HOMO: sp^3 on O in hydroxide
LUMO: O-H σ^* in propanoic acid
 - None of these choices is correct
13. What is the correct IUPAC name for this molecule?



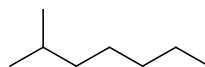
- 2-bromo-3,4,5-triethyl-6-methylheptane
 - 2-bromo-3,4-diethyl-5-isopropylheptane
 - 6-bromo-3,4,5-triethyl-2-methylheptane
 - 6-bromo-4,5-diethyl-3-isopropylheptane
 - None of these
14. Which of these compounds do you expect to have the lowest boiling point?



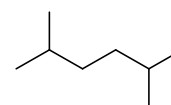
A



B

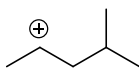


C

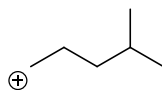


D

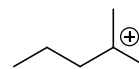
15. Place these three carbocations in order of *increasing* stability.



L

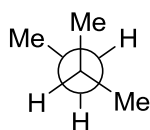


M

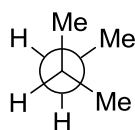


N

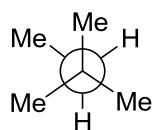
- a. L < M < N
b. L < N < M
c. M < L < N
d. N < L < M
e. N < M < L
16. Which of the following is the **most stable staggered conformation** of 2-methylbutane, looking down the C2-C3 bond? (Me = Methyl, CH₃)



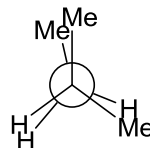
A



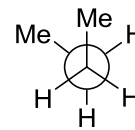
B



C



D



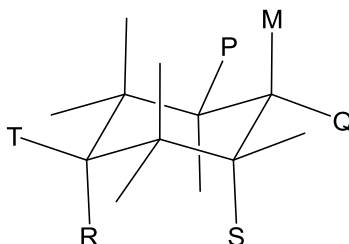
E

17. The carbon-carbon bonds in cyclopropane are described as

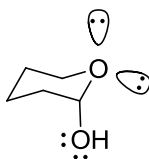


- a. Grande Decaf Latte bonds
b. New Mountain Berry Blast[®]™ bonds
c. X-Treem Mango Splash[™] bonds
d. Banana bonds
e. Bieberbonds

18. In this structure, what is the relationship between the groups P and M?

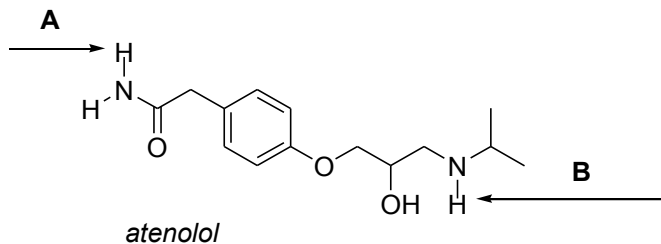


- gauche
 - anti
 - eclipsed
 - none of these
19. Alkyl groups prefer to occupy equatorial bonds on cyclohexane rings to avoid the steric strain present in the axial conformer. However, in the structure shown below, the OH group prefers to occupy the axial position. One theory for this preference involves hyperconjugation. Recalling that hyperconjugation involves the interaction of a filled orbital and an empty orbital, what two orbitals are involved in this structure that would account for the preference of the OH group to be axial?

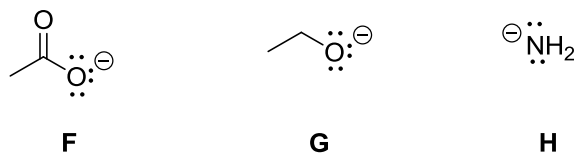


- Lone pair on O (sp^3) and O-H σ^*
- Lone pair on O (sp^3) and C-C σ
- Lone pair on O (sp^3) and p
- Lone pair on O (sp^3) and C-O σ^*
- C-H σ and O-H σ^*

20. Atenolol is a beta blocker used to treat high blood pressure. Which of the indicated H atoms, "A" or "B", is more acidic?



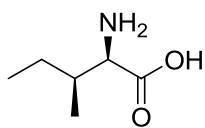
- a. A
 b. B
 c. They are equally acidic
21. Which statement correctly describes the relative base strengths of these three bases?



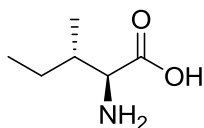
- a. G is the weakest base, F is the strongest base
 b. H is the weakest base, F is the strongest base
 c. F is the weakest base, H is the strongest base
 d. G is the weakest base, H is the strongest base
 e. H is the weakest base, G is the strongest base
22. Select the weakest acid from these choices.

- a. H₂O
 b. CH₄
 c. NH₃
 d. HBr
 e. CH₃OH

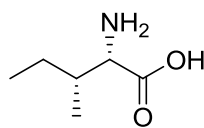
23. Which of the following is a pair of diastereomers?



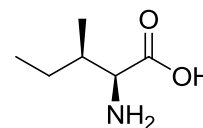
P



Q

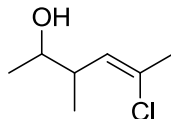


R

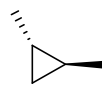
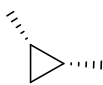


S

- P and R
 - R and S
 - P and S
 - P and Q
 - None of these combinations are diastereomers
24. What is the correct name for this molecule?



- (Z)-3-chloro-4-methyl-2-hexen-5-ol
 - (E)-3-chloro-4-methyl-2-hexen-5-ol
 - (Z)-5-chloro-3-methyl-4-hexen-2-ol
 - (E)-5-chloro-3-methyl-4-hexen-2-ol
 - None of these
25. Gas chromatography (GC) is an analytical tool that separates compounds based on their boiling points. Each compound that has a unique boiling point will generate one peak in the GC spectrum. You are using GC to analyze a mixture that contains equal parts of each of the four isomers of dimethylcyclopropane:



What is the maximum number of peaks that will appear in the GC spectrum? (Hint: You do not have to be taking the lab to answer this question.)

- None
- 1
- 2
- 3
- 4