

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																								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 *	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]	dubnium 105 Db [262]	seaborgium 106 Sg [269]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	unnilium 110 Uu [271]	ununium 111 Uuu [272]	unbinium 112 Uub [271]																								

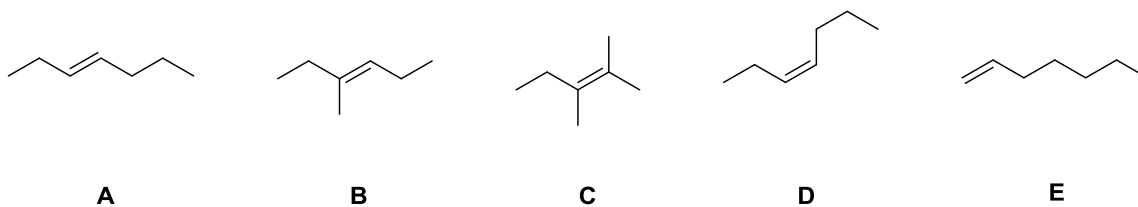
* Lanthanide series

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
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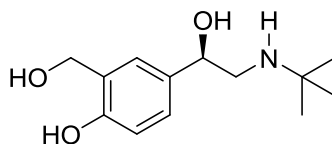
** Actinide series

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]
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1. Rank these C₇ alkene isomers in order of increasing stability (from least stable to most stable).

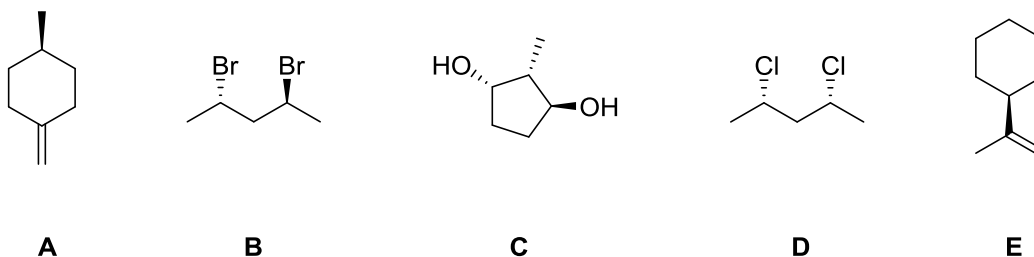


- a. E < D < A < B < C
 b. E < D = A < B < C
 c. E < D < B < A < C
 d. E < D < B < C < A
 e. E < A < D < B < C
2. Levalbuterol is a drug that has been used in the treatment of asthma and marketed under the name Xopenex. It is one of the enantiomers of albuterol, which is the name of the racemic mixture that is also used in respiratory therapy. What is the absolute configuration at the asymmetric carbon in levalbuterol?

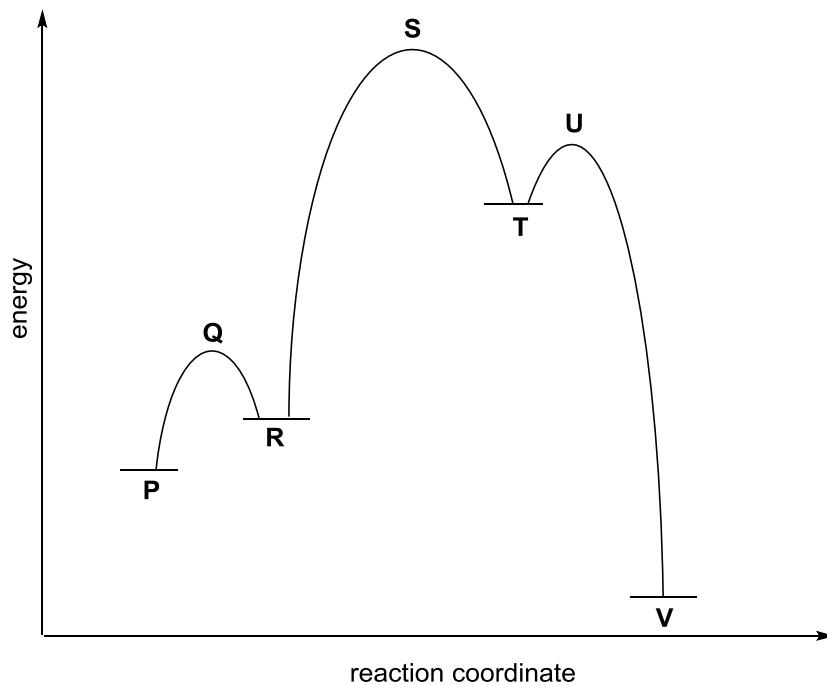


Levalbuterol (Xopenex)

- a. R
 b. S
3. Select the meso compound from this set of structures.



4. Consider the energy vs. reaction coordinate diagram shown below for a multi-step reaction:



- According to the diagram, which is the rate limiting step?
- $P \rightarrow R$
 - $R \rightarrow T$
 - $R \rightarrow S$
 - $T \rightarrow U$
 - $T \rightarrow V$
5. Which of the chemical species (represented by letters) in the energy diagram in #4 have bonds that are not fully formed?
- Q, S, U
 - R, T
 - Q, R, S, T, U
 - S only
 - All of the chemical species have fully formed bonds

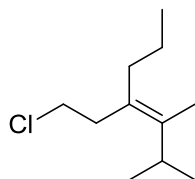
6. According to the Hammond postulate, which steps in the reaction shown in #4 have transition states that resemble the product(s) of the step both structurally and energetically?

- a. First step
- b. Second step
- c. Third step
- d. First and second steps
- e. All steps

7. Cyclobutane has two major conformations, planar and puckered. The puckered conformation partially relieves _____ strain.

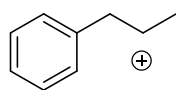
- a. Angle
- b. Torsional
- c. Van der Waals
- d. Angle and torsional

8. What is the configuration of this alkene?

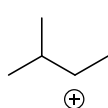


- a. *E*
- b. *Z*
- c. Neither *E* nor *Z*

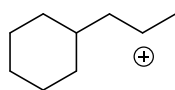
9. Which of these carbocations is least likely to undergo a single hydride shift to produce a more stable carbocation?



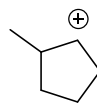
A



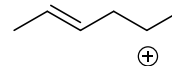
B



C

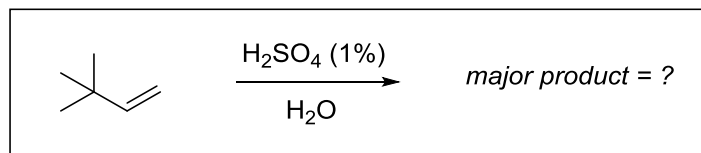


D

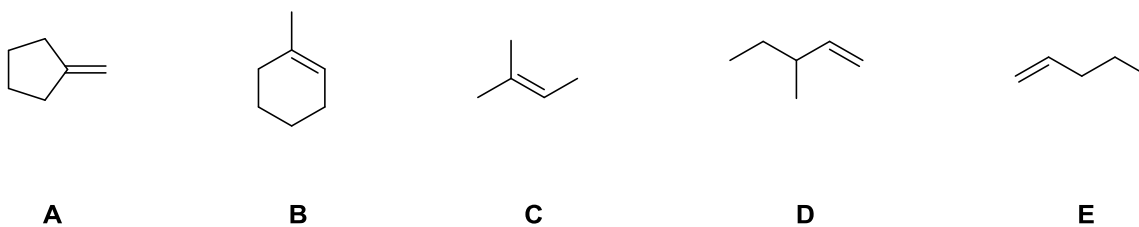


E

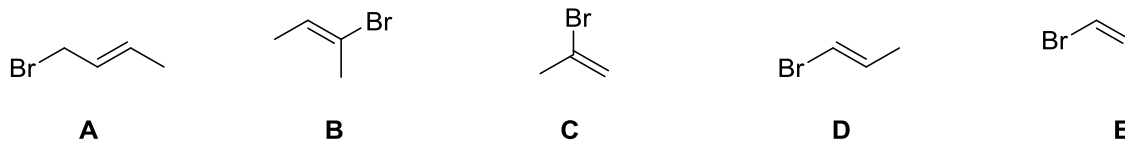
10. A student ran the following reaction:



- What is the name of the *major product* that the student isolated?
- a. 2,2-dimethyl-1-butanol
b. 2,3-dimethyl-1-butanol
c. 3,3-dimethyl-1-butanol
d. 2,3-dimethyl-2-butanol
e. 3,3-dimethyl-2-butanol
11. Each of these alkenes can be treated with catalytic sulfuric acid in water OR oxymercuration-demercuration. In all cases except one, either reaction will give you the same product. Which alkene gives a different product depending on which reaction you use?

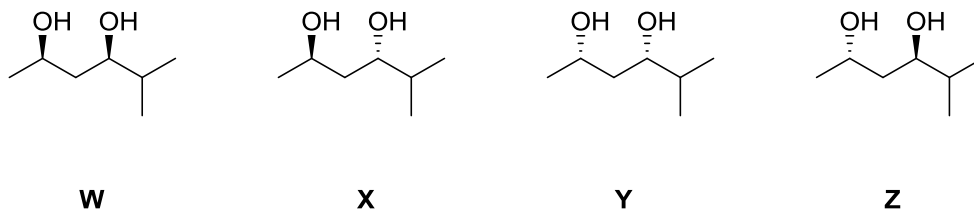


12. Which structure is *E*-1-bromoprop-1-ene (also known as *E*-1-bromo-1-propene)?

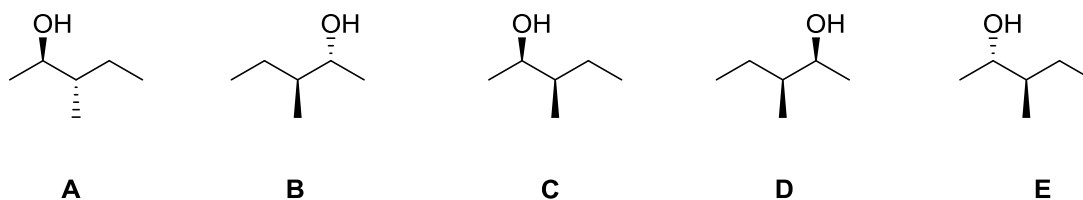


13. How many unique stereoisomers exist for 1,2,3-trichlorocyclohexane?
- a. 2
b. 3
c. 4
d. 5
e. 6

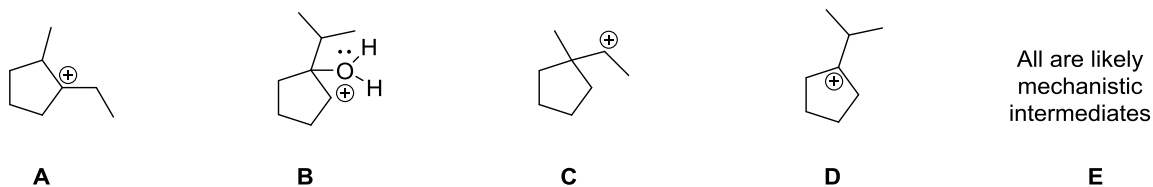
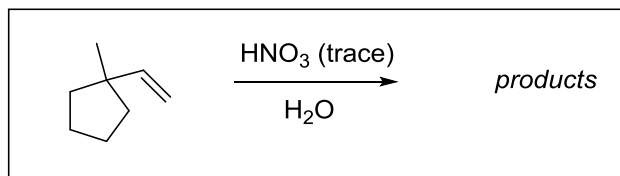
14. How many unique pairs of enantiomers exist in this set of stereoisomers?



- One
 - Two
 - Three
 - None of the structures are related to each other as enantiomers
15. Which of these structures is (2*R*,3*R*)-3-methyl-2-pentanol?

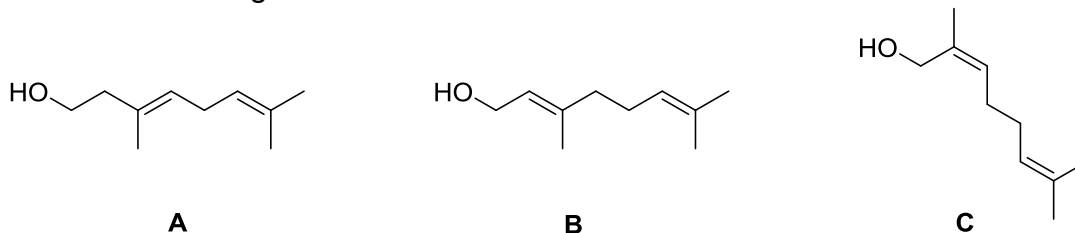


16. Which of these structures is the least likely mechanistic intermediate under the reaction conditions shown in the box?

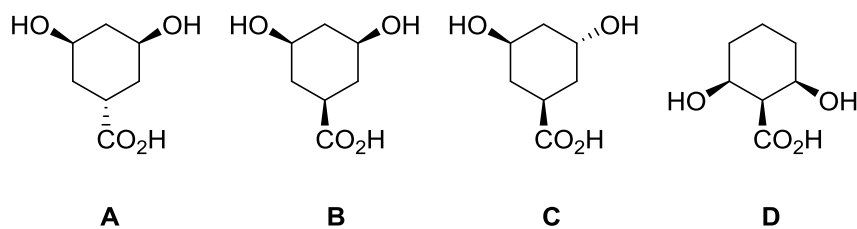


All are likely mechanistic intermediates

17. Geraniol is a naturally occurring compound with an odor of roses. Its molecular formula is $C_{10}H_{18}O$. Geraniol has methyl groups at C-3 and C-7, an OH group at C-1, and two double bonds, one at C-2 and the other at C-6. The double bond at C-2 has the *E* configuration. Which of these structures is geraniol?

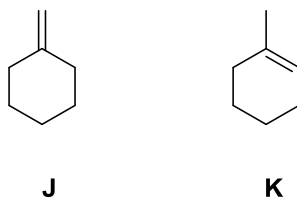


18. Consider these four structures:

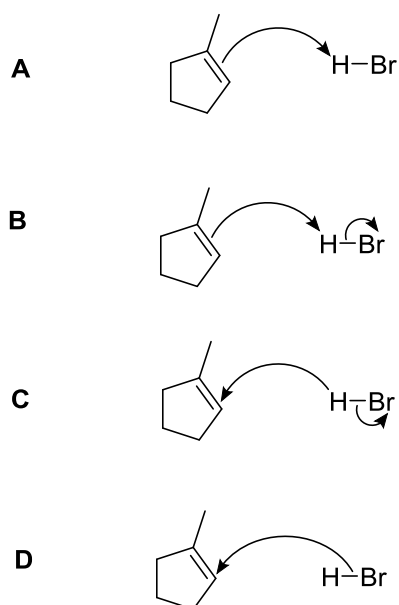
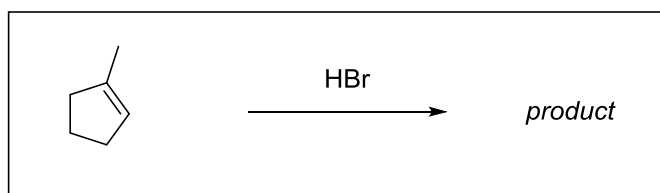


Three are stereoisomers; one is a constitutional isomer of the other three. Only one of these isomers rotates plane-polarized light. Which is it? (“ CO_2H ” is an abbreviation for the Lewis structure of a carboxylic acid.)

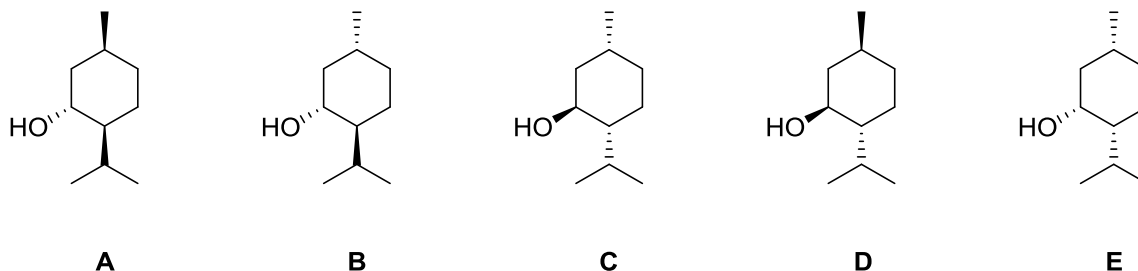
19. When each of the two alkene isomers shown is protonated by HBr, the same carbocation intermediate is formed. Which isomer is protonated faster?



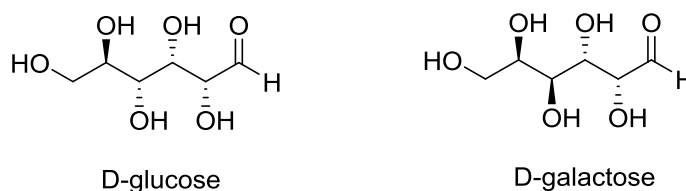
- a. J
b. K
c. They react at the same rate because each forms the same carbocation.
d. They react at the same rate because carbocation formation is endothermic.
d. The relative rates cannot be determined
20. Which of these choices shows the correct way to draw the first step of the mechanism for the reaction in the box? (Lone pairs on Br are omitted for clarity.)



21. Menthol, a component of mint oil, is 2-isopropyl-5-methylcyclohexanol. It is most commonly encountered in nature as the (1*R*,2*S*,5*R*) stereoisomer, which has a specific rotation of -50° . Which of these stereoisomers of menthol will have a specific rotation of $+50^\circ$?

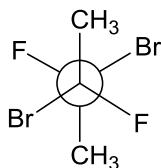


22. The structures of D-glucose and D-galactose are shown. What is the relationship between these two molecules?



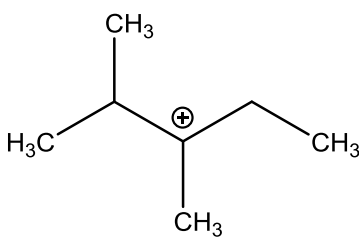
- a. Constitutional isomers
 - b. Diastereomers
 - c. Enantiomers
 - d. Identical
23. What is the name of the most stable conformation of cyclopentane?
- a. Banana
 - b. Chihuahua
 - c. Envelope
 - d. Spider
 - e. Boat

24. What is the correct description of this molecule?



- a. Chiral
- b. Achiral
- c. Achiral and meso

25. In class, we learned that carbocations are stabilized by hyperconjugation. Which of the following orbitals is/are participating in this type of stabilization for the carbocation shown below?



- a. C-H σ
- b. C-C σ
- c. C-H σ^*
- d. Both a and b
- e. a, b, and c