

*Key*

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

Period 1																		Period 2																			
1	H																	2	He																		
Period 3												Period 4					Period 5																				
3	Li	4	Be											5	B	6	C	7	N	8	O	9	F	10	Ne												
Period 6												Period 7					Period 8																				
11	Na	12	Mg											13	Al	14	Si	15	P	16	S	17	Cl	18	Ar												
Period 9												Period 10					Period 11																				
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr		
Period 12												Period 13					Period 14																				
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe		
Period 15												Period 16					Period 17																				
55	Cs	56	Ba	57-70	*	71	Lu	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
Period 18												Period 19					Period 20																				
87	Fr	88	Ra	89-102	**	103	Lr	104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Uun	111	Uuu	112	Uub	113	Uuq	114	Uuq	115	Uub	116	Uub	117	Uub	118	Uub

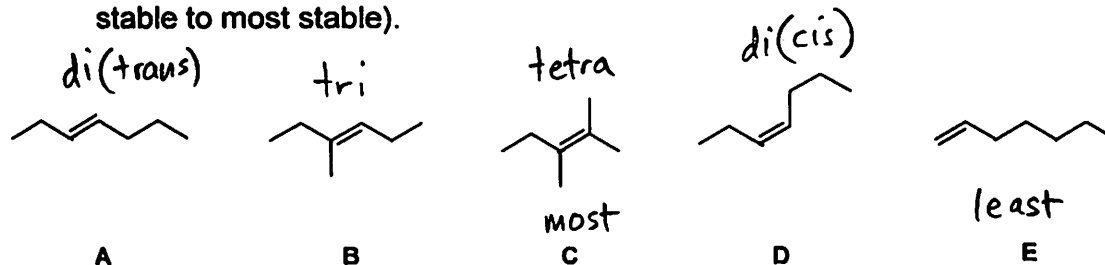
\* Lanthanide series

57	58	59	60	61	62	63	64	65	66	67	68	69	70
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb

\*\* Actinide series

89	90	91	92	93	94	95	96	97	98	99	100	101	102
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

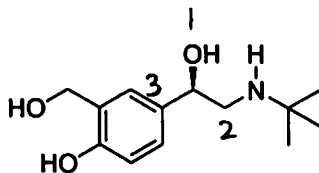
1. Rank these C<sub>7</sub> alkene isomers in order of increasing stability (from least stable to most stable).



A

- 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?

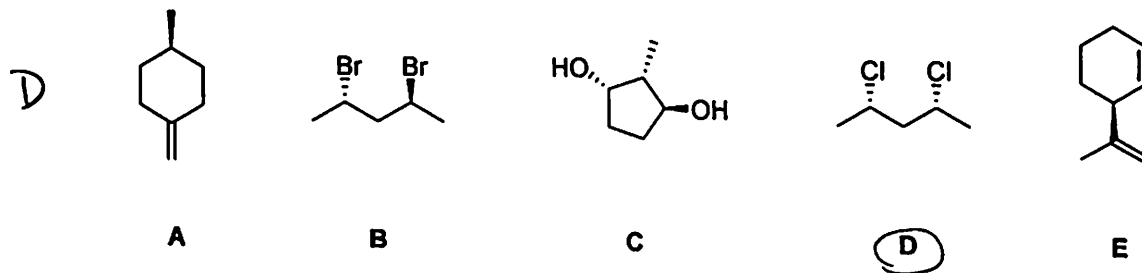


*Levalbuterol (Xopenex)*

A

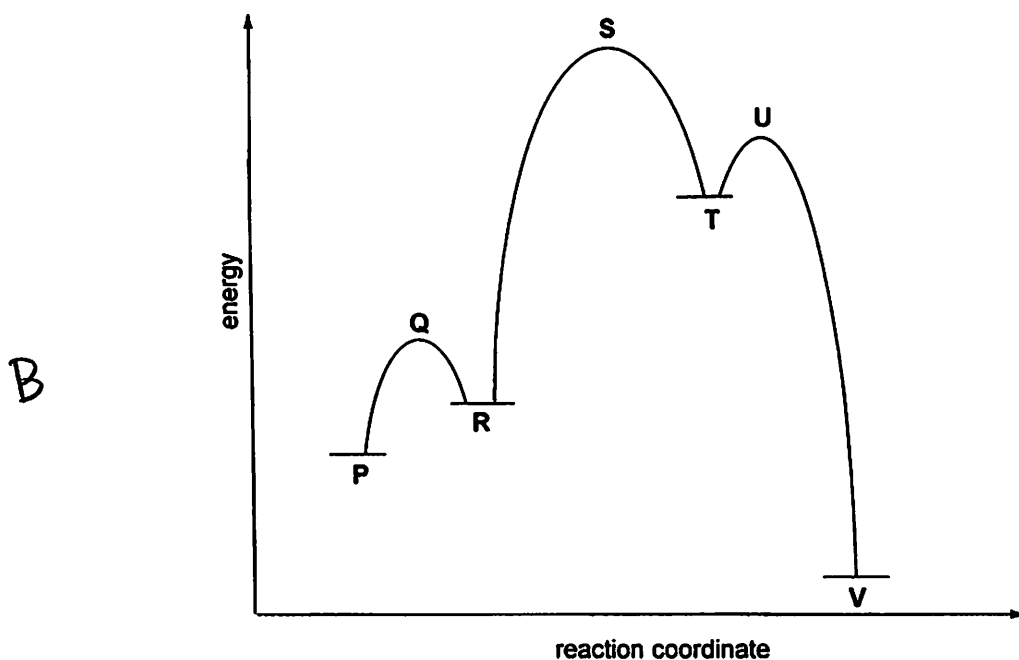
- a. R  
 b. S

3. Select the meso compound from this set of structures.



D

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?

- a. P → R  
 b. R → T Highest E ≠  
 c. R → S  
 d. T → U  
 e. T → V

5. Which of the chemical species (represented by letters) in the energy diagram in #4 have bonds that are not fully formed?

- A
- a. Q, S, U Transition states  
 b. R, T  
 c. Q, R, S, T, U  
 d. S only  
 e. 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?

D

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

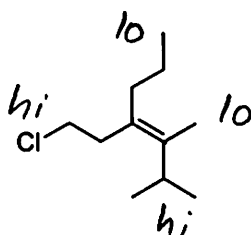
7. Cyclobutane has two major conformations, planar and puckered. The puckered conformation partially relieves \_\_\_\_\_ strain.

B

- a. Angle
- b. Torsional (it worsens angle strain)
- c. Van der Waals
- d. Angle and torsional

8. What is the configuration of this alkene?

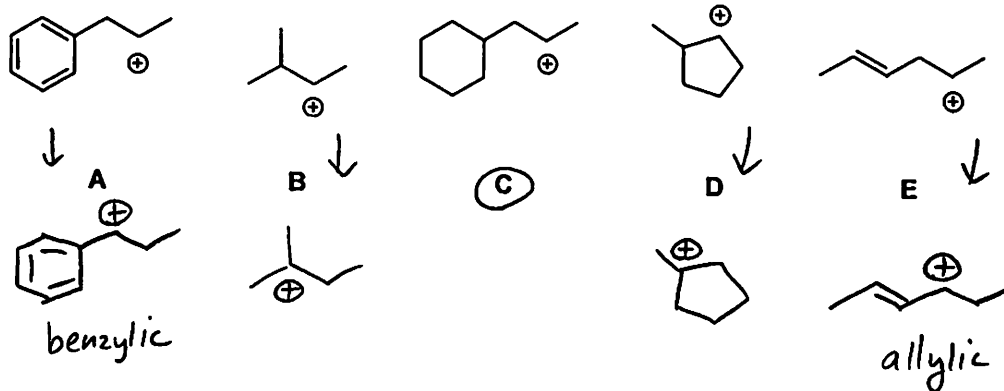
B

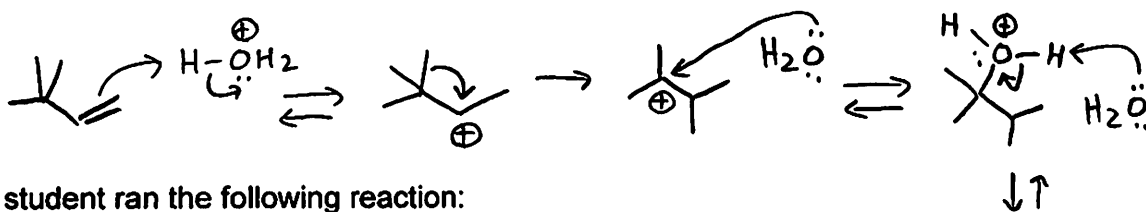


- a. E
- b. Z
- c. Neither E nor Z

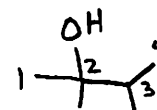
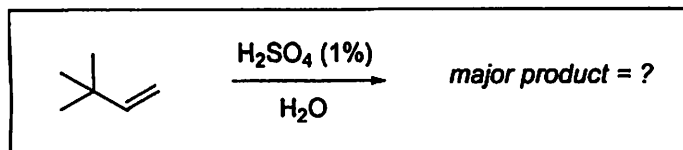
9. Which of these carbocations is least likely to undergo a single hydride shift to produce a more stable carbocation?

C





10. A student ran the following reaction:



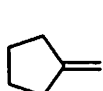
D

What is the name of the *major product* that the student isolated?

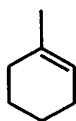
- a. 2,2-dimethyl-1-butanol
- b. 2,3-dimethyl-1-butanol
- c. 3,3-dimethyl-1-butanol
- d. 2,3-dimethyl-2-butanol
- e. 3,3-dimethyl-2-butanol

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?

D



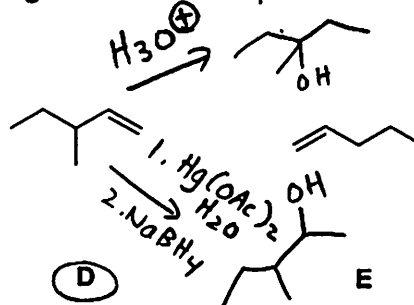
A



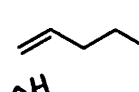
B



C



D



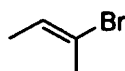
E

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

D



A



B



C



D

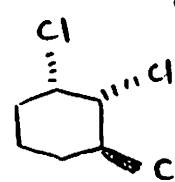
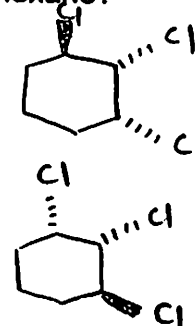
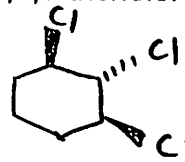
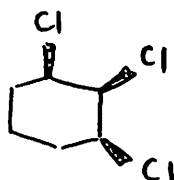


E

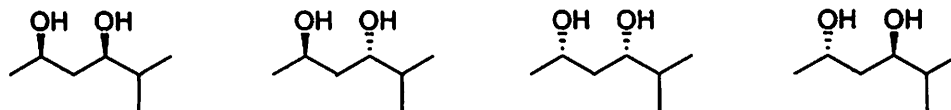
13. How many unique stereoisomers exist for 1,2,3-trichlorocyclohexane?

C

- a. 2
- b. 3
- c. 4
- d. 5
- e. 6



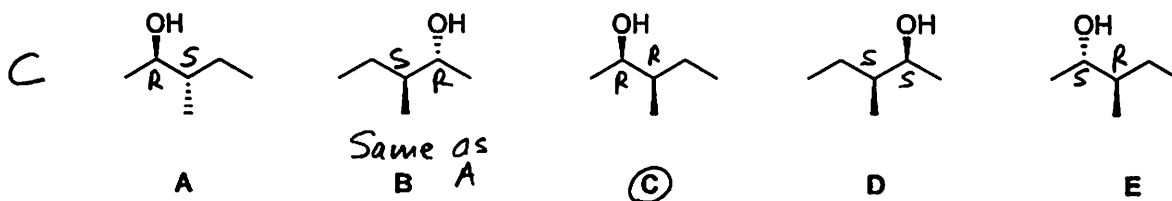
14. How many unique pairs of enantiomers exist in this set of stereoisomers?



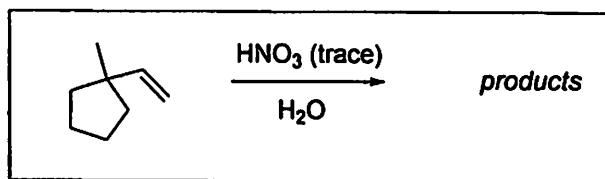
B

- W X Y Z
- a. One  
**b. Two**  
 c. Three  
 d. None of the structures are related to each other as enantiomers
- Handwritten notes:*  
 W, Y enant  
 W, X diast  
 W, Z diast  
 X, Y diast  
 X, Z enant  
 Y, Z diast

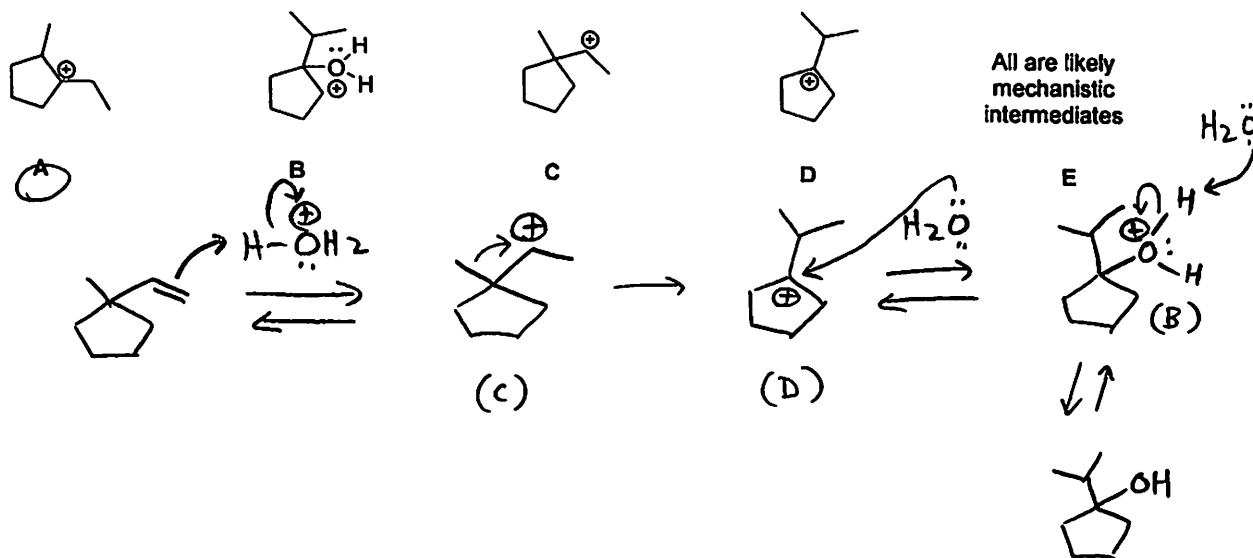
15. Which of these structures is (2R,3R)-3-methyl-2-pentanol?



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

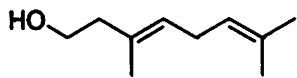


A

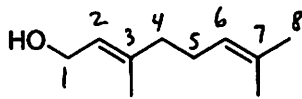


17. Geraniol is a naturally occurring compound with an odor of roses. Its molecular formula is  $C_{10}H_{18}O$ . Geraniol has methyl groups at C-3 and C-7, an OH group at C-1, and two double bonds, one at C-2 and the other at C-6. The double bond at C-2 has the *E* configuration. Which of these structures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

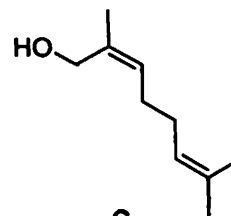
B



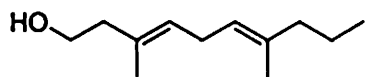
A



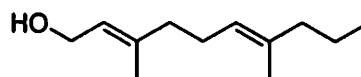
(C<sub>10</sub>)  
B



C



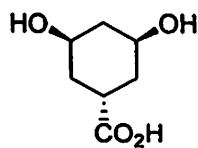
D



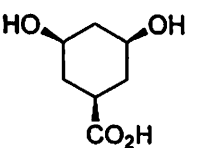
E

18. Consider these four structures:

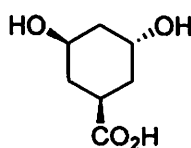
C



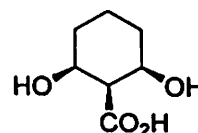
achiral, meso  
A



achiral, meso  
B



C

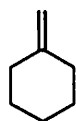


achiral, meso  
D

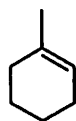
Three are stereoisomers; one is a constitutional isomer of the other three. Only one of these isomers rotates plane-polarized light. Which is it? ("CO<sub>2</sub>H" is an abbreviation for the Lewis structure of a carboxylic acid.)

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

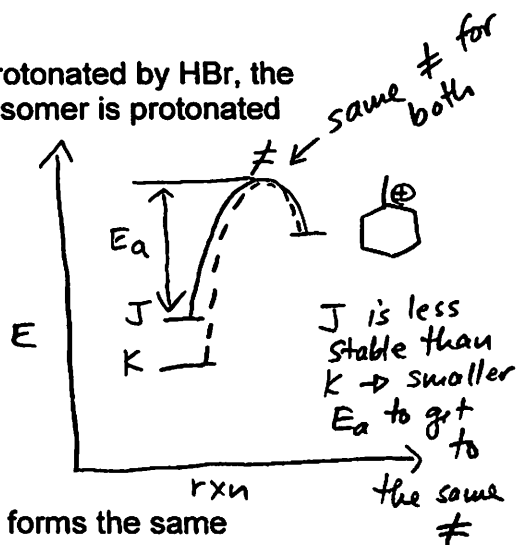
A



J



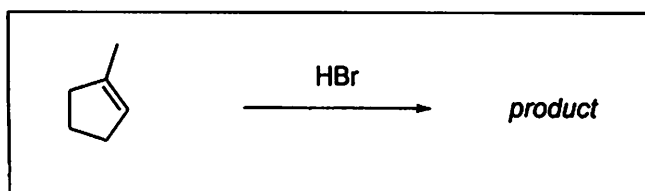
K



- 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.)

B



A



B



C



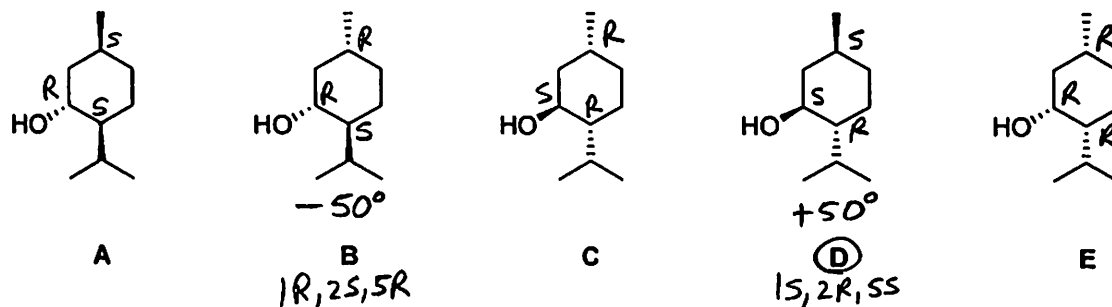
D





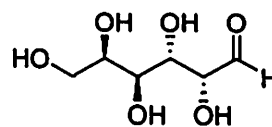
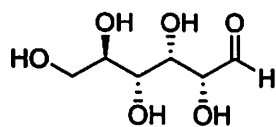
21. Menthol, a component of mint oil, is 2-isopropyl-5-methylcyclohexanol. It is most commonly encountered in nature as the (1*R*,2*S*,5*R*) stereoisomer, which has a specific rotation of  $-50^\circ$ . Which of these stereoisomers of menthol will have a specific rotation of  $+50^\circ$ ? *Its enantiomer*

D



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

B

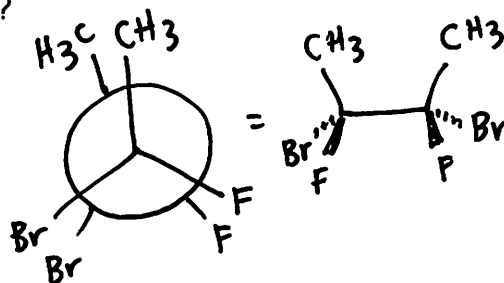
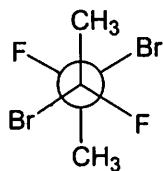


- a. Constitutional isomers  
 b. Diastereomers  
 c. Enantiomers  
 d. Identical
23. What is the name of the most stable conformation of cyclopentane?

C

- a. Banana  
 b. Chihuahua  
 c. Envelope  
 d. Spider  
 e. Boat

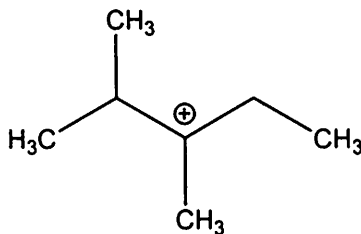
24. What is the correct description of this molecule?



C

- 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?



D

- a. C-H  $\sigma$
- b. C-C  $\sigma$
- c. C-H  $\sigma^*$
- d. Both a and b
- e. a, b, and c